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Contents

On the Mechanism of the Visual Threshold and Visual Adaptation: *George Wald* 887

News and Notes

Society of American Bacteriologists; and Regular Departments 893

Book Reviews

Projective Geometry and Projective Metrics; Robert Grossteste and the Origins of Experimental Science; The Challenge of Man's Future; Dielectric Aerials; Solubilities of Inorganic and Organic Compounds; and New Books 901

Miscellaneous Publications 903

Technical Papers

The Primary Radical Yield in Irradiated Water: *J. Rowbottom* 904

Three-Dimensional Movies without Special Equipment: *R. Stuart Mackay* 905

Incorporation of C^{14} into Various Carbohydrates of Tobacco Leaves after Different Periods of Photosynthesis in $C^{14}O_2$: *P. V. Vittorio, G. Krotkov,* and *G. B. Reed* 906

Communications

A Radiocarbon Date of Peat from James Bay in Quebec: *J. E. Potzger* and *Albert Courtemanche* 908

An Ethical Problem for Scientists in a Divided World: *Theodosius Dobzhansky* 908

A Challenge to Law: Discussions by *D. R. Rexworthy* and *Lawson M. McKenzie* 909

Need for a Standardized International Glossary of Terms in Botany: *Divya Darshan Pant* 910

Stable Colloidal Sulfur Solutions: *M. W. Brenner* and *Joseph L. Owades* 911

Transplantability of Tumors: Discussions by *Jacob Heiman* and *Robert H. Foulkes* 911

Alas for Human Frailties! *Joseph H. Friend* 912

Effects of Itrumil (New Antithyroid Agent) on the Histological Structure of the Rat Thyroid: *Walter O. Bradley* 912

A Simple Method for the Photographic Reproduction of Pencil Drawings: *E. J. Britten* 913

The Problem of the Carbonate Apatites: *Duncan McConnell* 913

Variation of Susceptibility to Polio: *Wallace L. Minto* 914

Types of Articles for *Science* 5A

Meetings & Conferences 10A

Index to Volume 119 ..... *i*

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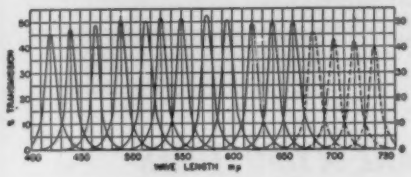

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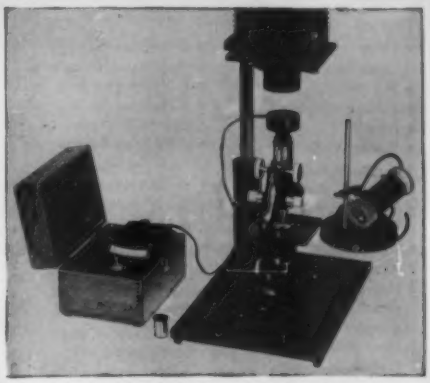

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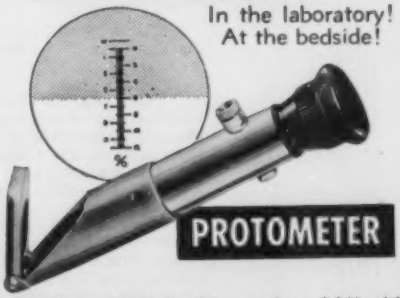

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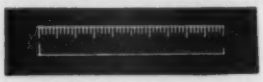

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On the Mechanism of the Visual Threshold and Visual Adaptation

George Wald*

Biological Laboratories of Harvard University, Cambridge, Massachusetts

IT is a matter of common experience that the eye loses sensitivity in the light and regains it in darkness. These are the phenomena of light and dark adaptation. They have commonly been ascribed to the bleaching and resynthesis of visual pigments—rhodopsin in the rods, other pigments in the cones.

This hypothesis rests upon the observation that the visual pigments are engaged in reversible cycles of bleaching and regeneration in the retina, and upon the assumption that the visual sensitivity (1/threshold) falls and rises with their concentration. Hecht (*1*) at one time assumed that the concentration of visual pigments, rod and cone, is proportional to 1/log threshold. In this case, a large change in threshold might accompany a relatively small change in pigment concentration. Later it seemed better justified to assume that the concentration of visual pigment is proportional to 1/threshold—that is, to the visual sensitivity (*2*). Neither assumption succeeded in bringing the chemistry of visual systems into quantitative agreement with the properties of light and dark adaptation (*2, 3*). Yet the notion has persisted that the alterations of visual sensitivity in light and dark adaptation reflect principally changes in the concentration of the visual pigments and, hence, of their capacity to absorb light.

Some years ago, however, Granit and coworkers (*4, 5*) reported that large changes in the electrical response of the retina—the so-called *b*-wave of the retinal potential—in light and dark adaptation involve only minor changes in the concentration of rhodopsin. Measured in this way, much of light and dark adaptation seemed to depend primarily upon the first fraction of rhodopsin to be bleached and the last to be resynthesized. It was suggested that only a small fraction of the rhodopsin of a rod, perhaps concentrated at its surface, may be directly concerned with excitation and adaptation, and that the great bulk of the rhodopsin may represent a physiologically inert store from which the material at the active site is replenished by diffusion (*4*).

The opinion that a considerable light adaptation can be achieved with little bleaching of visual pigment has since been expressed a number of times. Rose (*6*), having analyzed the behavior of ideal "picture pickup" devices—artificial or visual—concluded that only a small fraction of the change of visual sensitivity in light and dark adaptation can be ascribed to changes in the capacity of the visual pigments to absorb light, that is, to bleaching. Baumgardt (*7*) and Pirenne and Denton (*8*) have calculated that at moderate illuminations too little light reaches the rods to produce a bleaching of rhodopsin commensurate with light adaptation. Hagins and Rushton (*9*) have shown that in the eye of the living albino rabbit, long-continued exposure to light as intense as 10^5 times the human absolute threshold causes no appreciable bleaching of rhodopsin. (This is not as surprising as it sounds; a light of this luminance—about 0.1 millilambert—causes also relatively little rise of threshold.) With further rise of intensity, the rhodopsin of the retina does bleach and may, indeed, bleach almost entirely (*9, 10*).

One of the most significant contributions to this development is the study by Hartline and coworkers of light and dark adaptation in single receptors of the eye of the horseshoe crab, *Limulus*. Here, although visual adaptation pursues a course much as in the vertebrate eye (*11*), it probably involves little bleaching of visual pigment (*12*). On the other hand, the number of quanta of light that must be absorbed to stimulate a visual response—the quantum demand—rises during light adaptation by amounts sufficient in themselves to account very nearly for the entire rise of threshold (*13*). Bouman and ten Doesschate (*14*) have presented evidence for a similar rise of quantum demand with light adaptation of the human eye.

Recently Rushton and Cohen (*15*) have given us the most explicit statement of this situation as it involves human vision. They state that exposure of the eye to a light which should have bleached only about 2 percent of its rhodopsin raises the visual threshold about 100 times.

Reluctant that anything—even a calculation—intrude upon so important a datum, I have performed the following experiment.

A replica of a human eyeball was blown from glass (Fig. 1). It has a short neck closed with a ground-glass stopper, through which it can be filled with water. It then mimics closely the optical system of the human eye (posterior focal length, 22.3 mm; front surface a spherical blister, like the cornea, of radius

* I should like to offer this paper to one of my former teachers, Otto Warburg, in this his 70th year. I know it will interest him that the organ of photosynthesis, the chloroplast, which possesses a microstructure much like that of a rod or cone, raises also functional problems closely related to those discussed here.

This research was supported in part by funds from the Rockefeller Foundation and the Office of Naval Research. I deeply appreciate the hospitality of the Institute for Advanced Study at Princeton, where this paper was written. I should like also to acknowledge the help of Ruth Hubbard and Paul K. Brown with the experiments.

about 6 mm). This "water eye" was placed behind a screen that bears a disk pierced with circular holes of various sizes to serve as pupils. It faced a large opal glass plate, illuminated from behind with white light. Close against the back of the water eye, which was slightly flattened, a small absorption cell, 10 by 2 by 2 mm, was held by a clip. The cell contained a solution of cattle rhodopsin, to which hydroxylamine (0.1*M*) had been added. This reagent binds the retinene liberated by bleaching in the form of retinene oxime, so preventing any regeneration of rhodopsin (*16*). Furthermore, retinene oxime, unlike retinene itself, has no appreciable absorption at 500 mμ, where the extinction of rhodopsin was measured; so in the presence of hydroxylamine all changes in extinction at 500 mμ involve rhodopsin alone. In this arrangement, I measured the bleaching of rhodopsin, using a 3-mm pupil, the water eye facing the opal glass plate set at a luminance of 324 millilamberts (300 ft-lamberts), at a distance of 7.3 cm. These measurements are shown in Fig. 2.

A dark-adapted subject (R. H.) was now placed with her eye in the position formerly occupied by the water eye, looking through a 3-mm artificial pupil, with all other conditions exactly as before. On separate occasions, she was exposed for 5 sec to luminances of 10, 324, and 1008 millilamberts, and her dark adaptation was measured. These data are shown in Fig. 3.

It is important for our purpose to know the visual threshold at zero time, the moment of turning off the adapting light (log I_0). To estimate this, the log threshold at complete dark adaptation (log I_f) was subtracted from all the measured values of log threshold (log I_t). It was found that $1/(\log I_t - \log I_f)$ plotted as a function of time yielded reasonably straight lines. These cut the zero time axis at $1/(\log I_0 - \log I_f)$, from which values of log I_0 are readily obtained. They are shown in Fig. 3 with crosses.

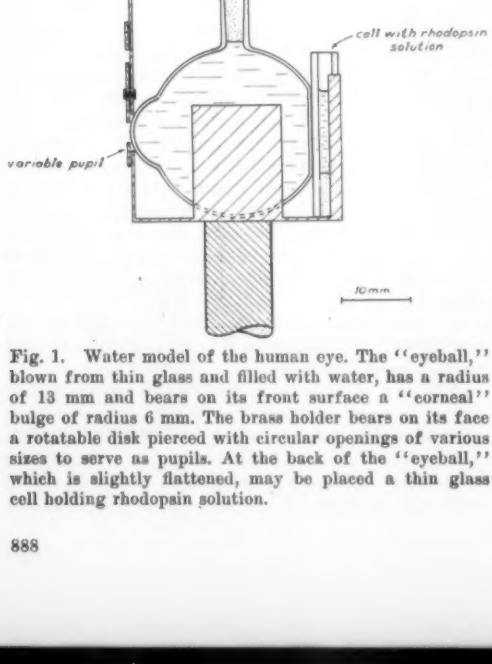

Fig. 1. Water model of the human eye. The "eyeball," blown from thin glass and filled with water, has a radius of 13 mm and bears on its front surface a "corneal" bulge of radius 6 mm. The brass holder bears on its face a rotatable disk pierced with circular openings of various sizes to serve as pupils. At the back of the "eyeball," which is slightly flattened, may be placed a thin glass cell holding rhodopsin solution.

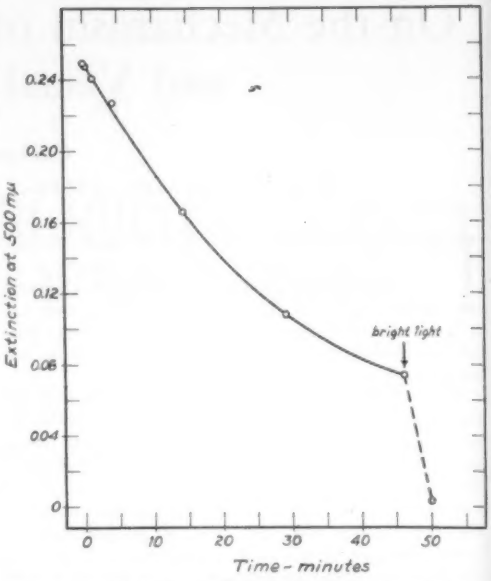

Fig. 2. Bleaching of rhodopsin in the "water eye." A solution of cattle rhodopsin containing 0.1*M* hydroxylamine was exposed to diffuse white light of luminance 324 millilamberts through a 3-mm pupil, and its bleaching was followed by measuring the fall in extinction at 500 mμ. After 47 min, the remaining rhodopsin was exposed to intense light to complete the bleaching.

Measurement of the bleaching of rhodopsin under one such set of conditions yields information under other conditions, since the rate of bleaching is directly proportional to the intensity of the light (*17*) and is independent of the temperature (*18*).

Table 1 brings together the results of this experiment. The first two columns show the conditions of irradiation; the third, the rise of visual threshold over the dark-adapted condition; and the fourth, the percentage bleaching of rhodopsin, measured in the water eye.

The exposure of the eye for 5 sec to 10 millilamberts raises the visual threshold about 8.5 times and bleaches 0.006 percent of the rhodopsin. Exposure of the eye to 324 millilamberts raises the threshold about 480 times and bleaches 0.2 percent of the rhodopsin. Exposure to 1008 millilamberts raises the threshold 3300 times and bleaches 0.6 percent of the rhodopsin. It should be noted that the conditions in the water eye all favored maximum bleaching. The transmission of light by this device is greater than by the eye; and the presence of hydroxylamine in the rhodopsin solution blocked all regeneration. I see no escape from the conclusion that a high degree of light adaptation can

Table 1. Human light adaptation and bleaching of rhodopsin. Comparison of the rise of visual threshold (rod) caused by exposure to lights of various luminance, with the percentage bleaching of rhodopsin measured under the same conditions in the water eye.

Light adaptation		Rise in dark-adapted threshold	Percentage bleaching of rhodopsin	Number of rhodopsin molecules bleached per rod
Luminance (millilamberts)	Duration (sec)			
10	5	× 8.5	0.006	1,200
324	5	× 480	.19	40,000
1008	5	×3300	.59	120,000

be achieved with very little bleaching of rhodopsin.

How many molecules do these small amounts of rhodopsin represent? A parafoveal human rod measures about 1.8 by 44 μ (*19*). The extinction of its rhodopsin at 500 mμ may be taken to be about 0.05. Some years ago, I estimated it to be about 0.12 on the basis of extractions of rhodopsin from retinas of other mammals (*20*); and recently Crescitelli and Dartnall (*21*), having extracted the rhodopsin from a single human retina, estimated that, if spread in an even layer over the retinal surface, it should have an extinction of 0.016. Judging by past experience with such methods of estimation, this is probably 2 to 5 times too low. I have taken 0.05 as a conservative value, which might almost equally well be too high or too low by a factor of 2. It corresponds to an absorption at 500 mμ of 10 percent.

From this value of the extinction, the volume of the rod, 112 μ^3, and the molar extinction of rhodopsin, 40,600 (*22*), we can calculate that a human rod contains about 3×10^{-17} mole, or about 18 million molecules of rhodopsin. Putting this together with the values of percentage bleaching shown in Table 1, we obtain estimates of the numbers of rhodopsin molecules bleached per rod (Table 1, column 5). We see that the exposure of the eye to 10 millilamberts for 5 sec, in raising the threshold about 8.5 times, bleaches at most 1200 molecules of rhodopsin per rod.

One can reach much the same conclusion in an independent way. A luminance of 10 millilamberts viewed with the natural pupil results in a *retinal* illumination of 1.9×10^{-6} lumen/mm² (*23*; also *7, 8*). For rod vision, by definition, 1 lumen at wavelength 507 mμ is equivalent to 1.37×10^{-4} cal/sec, or to 1.44×10^{15} quanta/sec. At this luminance, therefore, each square millimeter of retina receives $(1.9\times10^{-6})\times(1.44\times10^{15})$ $=2.7\times10^{9}$ quanta/sec. The cross-sectional area of the outer segment of a human rod is about 2.5×10^{-6} mm². Therefore, a single rod has incident upon it 6800 quanta/sec. If, as we suppose, about 0.1 of these are absorbed, the rod absorbs about 680 quanta/sec. With a 3-mm artificial pupil, as in my experiment, in place of the natural pupil, which at this luminance is about 4.32 mm, this value is reduced by the ratio of the pupil areas, 9/18.7, to 330 quanta absorbed per second, or 1650 quanta in 5 sec. All things considered, this value is in good agreement with the estimate in Table 1, that such an exposure bleaches about 1200 molecules of rhodopsin per rod.

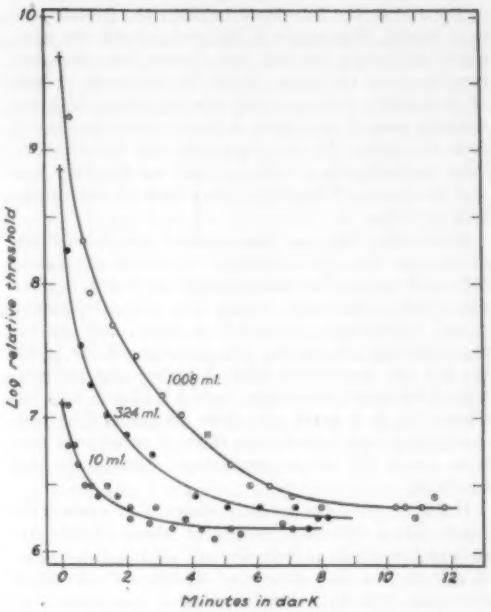

Fig. 3. Dark adaptation following 5-sec exposures to diffuse white light of luminance 10, 324, and 1008 millilamberts. A 3-mm artificial pupil was employed during light adaptation. The test field for the dark adaptation measurements subtended an angle of 1° with the eye and was fixated 10° below a small fixation point. The test light was of wavelength 436 mμ and was exposed for flashes of ⅛ sec. Thresholds in arbitrary units. Each dark adaptation begins with a threshold at zero time, obtained by extrapolation from the measurements as described in the text, and marked in the figure with a cross.

What do these relationships mean?

The outer segment of a rod or cone is a layered structure. That it is made up of transverse layers of microscopic dimensions has been known since the work of Max Schultze (*24*). In a frog rod, the layers may be very regularly spaced, a single cycle of alternate light and dark bands having a thickness of about 420 mμ (*25*). Studies with the polarizing microscope have shown that there must also exist a submicroscopic layering, of dimensions small compared with the wavelengths of visible light and associated apparently with alternate layers of protein and lipid, both highly oriented. This submicroscopic structure is believed to be responsible for the strong negative form birefringence observed in the intact rod [W. J. Schmidt (*26*)].

Some years ago, I suggested that rhodopsin, itself a lipoprotein composed of the protein opsin united with a carotenoid prosthetic group, might be situated

in the rod in the interfaces between the protein and lipid layers, with opsin in the protein and the carotenoid projecting into the lipid. In this case, the interfaces between the layers should be composed in part of rhodopsin; and one could estimate that a frog rod contains enough rhodopsin to form a large portion of such structures. It was suggested that the effect of light on rhodopsin is to disrupt such an interface, and that this in itself might be the source of rod excitation (*25, 27*).

Sjöstrand (*28*) has now revealed in the electron microscope the submicroscopic structure of certain rods and cones. The entire length of a rod (guinea pig, perch) appears to consist of a pile of regularly spaced membranes, associated in pairs, and consisting primarily of protein. The location of the lipids has not yet been determined. A guinea pig rod contains 1400 such membranes, each 4.1 (3.5 to 4.7) mμ thick (*29*). In a perch rod, there are about 2800 such membranes, each 8.0 ± 0.2 mμ thick. A perch cone contains about 800 single membranes, each about 16.6 mμ thick.

Hubbard (*30*) has recently shown that cattle rhodopsin has a molecular weight of about 40,000. Assuming the usual protein density of 1.4, this corresponds to a molar volume of 28,600 cm^3. A single rhodopsin molecule, therefore, has a volume of 47.7 $m\mu^3$. If spherical, this corresponds to a diameter of 4.5 mμ; if cubical, to a diameter of 3.6 mμ. That is, the diameter of a rhodopsin molecule is very close to the thickness of a membrane in a guinea pig rod. A membrane in a perch rod is twice this dimension; a membrane in a perch cone, 4 times this dimension.

From the molar extinction of rhodopsin, 40,600 (*22*), and the dimensions of a rhodopsin molecule, one can calculate that the extinction at 500 mμ of a monomolecular layer of rhodopsin, assuming spherical molecules tightly packed, is 4.25×10^{-4}. Suppose for a moment that the membranes of a guinea pig rod consist entirely of such monomolecular layers of rhodopsin. Then the rod would have a total extinction of $1400 \times 4.25 \times 10^{-4} = 0.60$. This is almost certainly too high, but probably by not more than 3 to 6 times. What it means is that the membranes of this rod, though not entirely rhodopsin, are probably 1/3 to 1/6 rhodopsin.

Again, the outer segment of a frog rod has a dry weight of about 3.5×10^{-10} g (*30*). About 35 percent of this is lipid. The nonlipid portion of the rod, therefore, weighs about 2.3×10^{-10} g. Hubbard (*30*) estimates that the extinction of this rod is about 0.50. Since its dimensions are about 6 by 50 μ, a rod contains about 3.5×10^{-15} mole of rhodopsin. If the entire nonlipid dry weight of the rod were rhodopsin, this substance would have a molecular weight of 66,000. This is, therefore, the maximum value that can be assigned to the molecular weight of frog rhodopsin.

On the other hand, we can be reasonably sure that the entire nonlipid moiety of the rod is not rhodopsin, and that this maximal value is almost surely too high. Accepting, instead, for frog rhodopsin the somewhat smaller value that Hubbard found for cattle rhodopsin, 40,000 (*30*), each frog rod should contain $3.5 \times 10^{-15} \times 40{,}000 = 1.4 \times 10^{-10}$ g of rhodopsin. This is about 61 percent of the nonlipid dry weight, or about 40 percent of the total dry weight of the rod. On a quite different basis, Hubbard has estimated rhodopsin to account for about 35 percent of the dry weight of a frog rod. It also accounts for about 14 percent of the dry weight of a cattle rod, or about 22 percent of the nonlipid dry weight.

The burden of these computations is that rhodopsin constitutes a large part of the protein of the rod and, hence, that it must also form a large part, and in some cases the major part, of Sjöstrand's membranes.

A further essential element in our argument is that *a dark-adapted rod may be stimulated by the absorption of a single quantum of light* (*7, 31*). One quantum of light is absorbed by 1 molecule of rhodopsin; and a rod is so peculiarly constructed that this change in a single molecule of rhodopsin can excite it.

This datum has another important consequence. Since *any* molecule of rhodopsin in the dark-adapted rod can produce this effect, *none of the rhodopsin of the rod can be inert*. All of it must be equally able to contribute to excitation.

I should like to propose the following hypothesis. The threshold of a dark-adapted rod depends upon its entire content of rhodopsin. The rod, however, is a compartmented structure, which can undergo, compartment by compartment, a stepwise response. Each compartment contains a considerable quantity of rhodopsin, any molecule of which, on absorbing a quantum of light, discharges the compartment. If there are n_0 compartments, when n_s of them have each absorbed at least 1 quantum of light, the threshold has risen $n_0/(n_0 - n_s)$ times. Thus, a large rise of threshold is achieved with very little bleaching of rhodopsin —a minimum of 1 molecule per compartment. A compartment on absorbing a first quantum of light makes its whole contribution to the response and cannot contribute again until all its rhodopsin is restored. The remaining rhodopsin of this compartment, though rendered temporarily inert for excitation, absorbs light, just as before. Such absorption can have no other effect than to delay the eventual recovery of the compartment.

What are the compartments? Enough has been said to suggest strongly that they have a close relationship to Sjöstrand's membranes. There seems little place for the rhodopsin of a frog or mammalian rod other than in the membranes; and in dimensions and numbers, the membranes satisfy very well the requirements of our hypothesis. Yet Sjöstrand finds both single and double membranes and, perhaps, substructures within the thicker single membranes. Furthermore, the rods of frogs and other amphibians exhibit a coarser, microscopic layering and longitudinal striations which may be fibrillae (*25*), no evidence of either of which appears in Sjöstrand's figures. Although I think it very probable that the compartments are closely associated with Sjöstrand's membranes, it is

too early yet to identify them; and I shall go on for the present referring to them simply as compartments.

The absorption of a first quantum of light by a dark-adapted rod—one in which all the compartments are intact—causes a first response. For a second quantum of light to excite, it must be absorbed in a new compartment. If absorbed in an already discharged compartment, it is wasted. The more compartments discharged, the more quanta absorbed to no avail. Therefore, the quantum demand begins at once to rise. Having been 1 in the dark-adapted rod, it rises to higher and higher values as more compartments respond. If there are n_0 compartments and n_x have been discharged, the quantum demand has risen $n_0/(n_0 - n_x)$ times—the same law that governs the rise of threshold. That threshold and quantum demand rise together in light adaptation has been demonstrated by Hartline *et al.* in the *Limulus* photoreceptor (*13*); and some evidence exists of a comparable phenomenon in the human eye (*14, 15*).

The absorption of the first quantum of light by a dark-adapted rod should raise its threshold $n_0/(n_0 - 1)$ times. When half of the compartments have been discharged, the threshold should have doubled; when 9/10 have been discharged, the threshold should have risen 10 times. When only two compartments remain intact, the absorption of a quantum by one of them doubles the threshold. Finally, the discharge of the last compartment projects the threshold to infinity; the rod is now inexcitable.

In these terms, Table 1 shows that a 5-sec exposure of the eye to 10 millilamberts leaves, on the average, $1/8.5 = 0.12$ of the compartments of the rod intact; 88 percent have been discharged. This has involved the bleaching of about 1200 molecules of rhodopsin. This number is in good accord with the suggestion that the compartments may be identical with Sjöstrand's membranes or membrane pairs.

It has already been noted that the absorption of light by an already discharged compartment causes no further response, nor does it raise the threshold further—it is already infinite—but it delays the eventual repair of that compartment. That is, such extra absorption of light and bleaching of rhodopsin in the compartments has the effect, not of raising the threshold of the rod, but of delaying its recovery—of slowing its subsequent dark adaptation.

It is well known that, in general, the higher the light adaptation, the slower the dark adaptation that follows (*32*). Figure 3 shows an example of this phenomenon. It is found equally in rods (*32*), cones (*33*), and single receptors of the *Limulus* eye (*11*).

After high light adaptation, most of the rhodopsin regenerated should go to restore the rhodopsin content of badly depleted compartments; but no compartment comes back into function until its *last* rhodopsin molecule has been regenerated. It is, therefore, the last stages of rhodopsin synthesis that should be most effective in restoring the compartments to function and so causing the fall in visual threshold that we measure as dark adaptation.

I think that this explains the observation by Granit *et al.* (*5*) that, following high states of light adaptation, dark adaptation measured electrophysiologically lags markedly behind the regeneration of rhodopsin. These workers found that, on shutting off a strong adapting light, which had bleached most of the retinal rhodopsin, the latter began to regenerate at once; but the *b*-wave of the retinal potentional remained very small (frog) or wholly absent (cat) until the rhodopsin had reached about 40 to 50 percent of its maximal concentration. Thereafter it rose rapidly. This is the behavior expected on the basis of the present hypothesis.

What of the cones? Large as rhodopsin looms in the microstructure of a rod, it occupies a correspondingly small position in the microstructure of a cone. Indeed, if it were necessary to bleach much pigment to stimulate a photoreceptor, it would be difficult to understand how a cone functions at all. The realization that stimulation is the business of single molecules of visual pigment absorbing single quanta of light disposes of this difficulty.

A cone, which possesses very little visual pigment and hence a small probability of absorbing light, has a correspondingly high threshold. If, as we have supposed in rods, the visual pigment of cones is distributed among a large number of compartments—perhaps the single membranes photographed by Sjöstrand—this arrangement has important consequences. Our general hypothesis remains unchanged; but in a structure that contains very little visual pigment it involves new considerations.

Consider the limiting case of a cone in which each compartment contains a single molecule of visual pigment, which by absorbing a quantum of light discharges it. Then in all stages of adaptation this cone would have a quantum demand of 1—each quantum absorbed would involve a new compartment and would result in a response. Also, the sensitivity of such a cone would at all times be proportional to its concentration of visual pigment. When half of the pigment had been bleached, half of the compartments should have been discharged, and the threshold should have doubled. Furthermore, in such a receptor, there would be no such slowing of dark adaptation with increase in light adaptation as we have described in the rods. For each molecule of visual pigment resynthesized, one compartment would come back into function; and the rate of dark adaptation would measure simply and directly the rate of synthesis of visual pigment.

I do not suppose that a cone exists with the properties just described; but the consideration of such a limiting case helps to clarify an important relationship. We see that many of the special complications of light and dark adaptation in the rods come directly out of their high concentrations of visual pigment. This is the particular source of disparities in their behavior from properties predicted by the simplest of photochemical theories. A receptor that possessed 1 molecule of visual pigment per compartment would

follow in detail the state of its photochemical system. A rod—entirely because it is highly overloaded with visual pigment—exhibits all the special phenomena we have considered: low threshold; rise of quantum demand with light adaptation; dependence of light and dark adaptation primarily upon the first fraction of visual pigment to be bleached and the last to be resynthesized; and the slowing of dark adaptation with the degree of bleaching achieved in light adaptation. For this reason, we can expect that the more dilute the visual pigment in a receptor, the less conspicuous should be all these properties. In general, therefore, they should be less conspicuous in cones than in rods.

Where do these considerations leave our concept of the visual threshold and visual adaptation?

In this discussion, I have called upon nothing but the chemistry of the outer segments of the rods and cones and their microstructure. I have no conviction that this is all, yet for the present it may be enough. The visual pathways include nerves, synapses, and a portion of the brain; and in time we should know what part these structures play in determining visual thresholds and adaptation. A number of special conditions are already known—anoxia, acidosis, and alkalosis—that cause fluctuations in the threshold of the completely dark-adapted eye, owing presumably to changes central to the photochemical systems of the receptors (*34*). The entire visual apparatus, however, hangs upon the initial action of light on the photosensitive pigments of the rods and cones, and it seems probable that under all ordinary conditions the pigments are the major determinants of visual threshold and adaptation.

We emerge, therefore, with a photochemical view of the threshold and its changes, a photochemistry, however, not as one would find it in solution, but intimately interwoven with the microstructure of the receptors. Once it had been shown that a rod can be excited by the absorption of a single quantum of light, this further development was inevitable. A process that depends upon single quanta must be considered chemically in terms, not of moles, but of molecules; and it is only within a superbly organized structure that 1 quantum acting upon 1 molecule could have so large an effect.

What I regard as most important in this situation, however, is the opportunity it offers to consider together the structure, chemical composition, and function of an excitatory tissue. Only at grosser levels of analysis can anatomy, chemistry, and physiology be dealt with separately. At the molecular level they are one and must be so regarded.

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News and Notes

Society of American Bacteriologists

On 2–7 May approximately 1800 scientists met in Pittsburgh to participate in the 54th annual meeting of the Society of American Bacteriologists. The Allegheny Branch, the host organization, provided admirable facilities. At the five concurrent scientific sessions, 339 papers on original research were presented. Abstracts were published in the *Bacteriological Proceedings* for 1954 (Williams & Wilkins Co., Baltimore). The diverse fields of microbiology were well represented, but more than usual attention was paid to virus-cell relationships, metabolic pathways, biosynthesis, and mycology. Only a few of the many outstanding papers can be mentioned here.

The removal of substances inhibitory to tetanus toxin formation in large-scale toxin production has been accomplished, using absorptive procedures, by Pauline A. Miller and the late J. Howard Mueller of Harvard University. Experimental studies on bacterial contamination of bank blood by Geller and Jawetz of the University of California indicated that undesirable reactions following use of such blood could be due to endotoxin of contaminating microorganisms, which made some growth during storage in a refrigerator.

Contributions to the understanding of carbohydrate metabolism in microorganisms came from the laboratories of Wood and of Krampitz and of Gest at Western Reserve, of Gunsalus at Illinois, of Lipman at Harvard, of Doudoroff and of Barker at California, of Wilson at Wisconsin, of Kaplan and of McElroy at Johns Hopkins, and of Horecker at the National Institutes of Health. The current concepts in this field were integrated in a symposium on "Diverse pathways of microbial metabolism" by a panel consisting of Horecker, Doudoroff, Krampitz, and Kallio, with H. G. Wood acting as convener.

A symposium on the "Steroid requirements of Protozoa," arranged by van Wagtendonk of Indiana University, included discussions by Helen Vishniac of Yale, Conner of Indiana, and Hutner of Haskins Laboratories. The Medical Division presented an outstanding symposium, the "Applications of tissue-culture methods to viral infections." This was convened by Enders of Children's Hospital, Boston, and included a presentation on "Use of tissue cultures in etiologic studies on viral diseases" by Weller of Children's Hospital; on "Mammalian cells in continuous cultures for assays in virology" by J. T. Syverton and W. F. Scherer of the University of Minnesota; on "Applications of tissue cultures to studies of poliomyelitis" by J. E. Salk and J. S. Younger of the University of Pittsburgh School of Medicine; on "Some factors affecting the metabolism of viruses in tissue culture" by G. C. Brown of the University of Michigan; and on "Interaction between animal viruses and neutralizing antibodies studied by the plaque technique in tissue cultures" by R. Dulbecco, M. Vogt, and A. G. R. Strickland of the California Institute of Technology.

An audience of more than 1200 members and guests crowded the ballroom to applaud enthusiastically and to comment critically on the excellent presentations in the symposium on bacterial cytology. Bartholomew of Southern California arranged and convened the session with the following participants: Chapman, Princeton University, "Electron microscopy of ultrathin sections of bacteria"; Henry Koffler, Purdue University, "The chemical nature and biological significance of bacterial flagella"; Stuart Mudd, University of Pennsylvania School of Medicine, "Bacterial mitochondria and metachromatic granules"; Georges Knaysi, Cornell University, "Recent advances in our knowledge of the structure of the bacterial cell wall and cytoplasmic membrane"; and Edward D. DeLamater, University of Pennsylvania School of Medicine, "A formulation of the mitotic mechanism in bacteria."

The annual banquet was honored by the presence of A. J. Kluyver, honorary member from Delft. President C. B. van Neil delivered his message to the membership and presented the Eli Lilly award to James W. Moulder of the University of Chicago and the Commercial Solvents award in Antibiotics to R. D. Hotchkiss of the Rockefeller Institute.

The business meeting approved a resolution addressed to the Secretary of the Department of Health, Education, and Welfare, expressing concern over the possibility of arbitrary action in excluding scientists from the research grant program of that Department because of information reflecting on the loyalty of such persons and asking the Secretary to rely on the National Academy of Sciences for aid in this matter. The Society also voted to proceed on a program of certification of bacteriologists. The 1955 meeting will be held in the Statler Hotel in New York and the 1956 meeting in the Shamrock Hotel in Houston.

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Science News

In a micro-optical study of the distribution of cellulose, hemicellulose, and lignin within the wood cell, Paul W. Lange of Stockholm University has found that the cellulose proper is contained in the inner portion of the cell wall, while the hemicellulose, so important for paper-making, is concentrated in the outer part. His results are expected to be of great value in connection with studies of the diffusion and penetration processes that take place in the fiber walls when wood is subjected to chemical procedures in pulp-making.

In connection with **J. Robert Oppenheimer's loss of security clearance,** 282 scientists at Los Alamos telegraphed a petition to the President, the Atomic Energy Commission, and the chairman of the Joint Congressional Atomic Energy Committee. The group warned that the action taken against Dr. Oppenheimer might make it difficult in the future to fill Government laboratories with trained workers, and that further "It is inexcusable to employ the personnel security system as a means of dispensing with the services of a loyal but unwanted consultant."

Fred L. Ribe, who gathered the 282 signatures in less than one day, indicated that they represented 80 percent of the Los Alamos scientific staff.

R. Hanbury Brown, H. P. Palmer, and A. R. Thompson report in the 15 May issue of *Nature* their discovery of **nine new radio "stars."** Three of these have been identified with nebulosities. The other six are probably associated with similar nebulosities, but their light is so faint that it has not yet been photographed. The nine radio stars all seem to have rather low temperatures, a few hundred degrees rather than the thousands or millions of degrees of most visual stars.

So far only five radio sources have been definitely identified with visual stars. Of these five, three are of the newly discovered type reported here. The first visual identity of one of these three has just been announced by R. Minkowski of Mount Wilson and Palomar Observatories; it is associated with a faint nebulosity in the constellation Auriga. The other two radio stars are quite different in kind from the three that are associated with nebulosities.

An **American Museum of Natural History expedition** has recently returned from Africa. Two specially constructed cars were used to cover the 13,000 mi between Casablanca and Cairo by way of the Sahara. The 4-mo trip was made for the museum's department of anthropology by Claude Bernheim, a New York businessman and his family. More than 20,000 ft of 16-mm color motion picture film was used for the varied geographic and cultural areas visited.

A principal interest of the expedition was the Tuaregs, a nomadic Sahara tribe that was once famous for its exploits against France's Foreign Legion. The group found that the tribe is becoming not only less numerous but more sedentary. Many aspects of tribal life were for the first time photographed and also recorded on tape. Ethnological material brought back included samples of native weapons, utensils, handicrafts, and a miniature Tuareg tent. The Tuaregs are Mohammedans, but it is the men who veil their faces, leaving only their eyes and foreheads bare. The expedition was able to obtain some of the first photographs of these men unveiled by agreeing to supply their subjects promptly with prints.

Public demand for dental health services has nearly doubled in less than a generation, the American Dental Association reported recently. From a nation-wide survey of dentists, the Association's Bureau of Economic Research and Statistics has estimated that in 1952 approximately 42 percent of the population—65 million persons—sought dental treatment, compared to some 20 to 25 percent in 1929.

A significant advance in understanding the **embryonic growth** of animal organs has come from experiments that followed up the previous discovery, made by Paul Weiss of the University of Chicago, that bits of liver or kidney tissue from older chicken embryos, when grafted onto the chorio-allantoic membranes of younger embryos, stimulate the growth of the corresponding organs in the young embryo that serves as host. In experiments involving nearly 3500 similar grafts, James D. Ebert of Indiana University [*Proc. Nat. Acad. Sci.* (May 1954)] has shown that adult chicken spleen or kidney evokes at least 2.4 times as much growth of the embryo's corresponding organs as of any other, nonhomologous organs. In other words, spleen stimulates the growth of spleen; kidney, that of kidney. The stimulation is also species-specific, for transplanted mouse spleen does not significantly enhance the growth of the spleen of the host chick embryo. By chemically analyzing the stimulated spleens of the host chick embryos for their relative content of protein and nonprotein nitrogen, Ebert has shown that the growth is primarily protein in nature.

Within as little as 3 days following the establishment of the graft, the transfer of substance, tagged with radioisotopes, from the grafted spleen to that of the embryo may amount to as much as 15 percent of the weight of the embryo's spleen. At the same time, the specificity of the response between grafted organ and corresponding host organ implies that the stimulating agent must be larger and more specific than amino acids; yet evidence is also provided that virtually rules out the possibility that any whole cells may move from the graft into the host embryo's spleen or kidney. In short, it now looks as though a growing organ can utilize tissue proteins or polypeptides without the necessity of first breaking them down into free amino acids. This result favors the idea that in growth, chemical "building-blocks" specific in nature to each type of organ are used, rather than the view that these must be made on the spot on some sort of template, and consequently that the stimulation in the aforementioned cases is due to a transfer of small, catalytic amounts of active substances.—B.G.

A **new isotope of element 100,** the element that was first reported by the University of California in April (*Science,* p. 460), has been isolated at the Nobel Institute of Physics, Frescati, Sweden. In contrast to the California work, which was done with a uranium reactor, the new isotope was isolated by means of cyclotron bombardment of uranium with carbon and oxygen nuclei. Californium, another recently found element of atomic number 98, was produced simultaneously with the unnamed element, and special processes had to be used to separate it. Altogether less

than 100 atoms of the new isotope have as yet been isolated. Headed by Manne Siegbahn, the investigators responsible for the discovery were Lars Melander, Vilhelm Forsling, Hugo Atterling, Lennart W. Holm and Björn Åström.

Word has been received of the death in Cambridge, England, of **Felix Eugen Fritsch,** emeritus professor of botany in the University of London, who was head of the department of botany at Queen Mary College from 1911 until he retired in 1948. Prof. Fritsch has been described as the most able student of the algae in Great Britain. He published extensively on freshwater algae and on general algal morphology; most notable among his books was *The Structure and Reproduction of the Algae.* He was influential in developing the Freshwater Biological Station on Lake Windermere and in many other important projects in England.

Scientists in the News

Leo S. Baldwin, chairman of the department of engineering drawing and descriptive geometry at the Milwaukee Extension Division of the University of Wisconsin, will retire this June after 35 yr of service. As a young man he worked for the Illinois Central Railroad where he learned the machinist and draftsman trades. At the suggestion of the railroad's divisional superintendent, he began his high school education at the age of 25. He entered Illinois College and afterward transferred to the University of Illinois, financing his education with his drawings and by working for the University's Materials Testing Laboratory. When he graduated in 1916, he had accumulated 204 credits and received two degrees at the same commencement, a B.S. degree in drawing and a B.A. degree in mathematics.

Prof. Baldwin remained at Illinois as an instructor of drawing and descriptive geometry until the outbreak of World War I. In 1919 he joined the University of Wisconsin and organized and taught a course in art lettering. In 1925 he wrote an art lettering correspondence course which is still offered by the Extension Division.

Prof. Baldwin began teaching at the Milwaukee Division in 1928, and at the start of the spring semester, 1929, he joined the Milwaukee faculty permanently as chairman of the department of engineering drawing and descriptive geometry. From 1942–46, he assumed additional duties as acting chairman of the engineering department. He supervised the expansion of both departments to meet the tide of veterans returning to college. In addition to his academic duties, Prof. Baldwin has completed considerable research in problems of industrial x-ray design. At one time, some 20 of his former students were vice presidents of Milwaukee business concerns.

Stanley S. Ballard will go to the La Jolla campus of the University of California about 1 July as a research physicist and as associate director of the Visibility Laboratory of the Scripps Institution of Oceanography. He has been on leave of absence this past academic year from his regular post as professor of physics and chairman of the department at Tufts College, and during this period has been a member of the electronics division of the Rand Corporation, Santa Monica, Calif.

A. C. Cohen, Jr., professor of mathematics at the University of Georgia, has received the $500 M. G. Michael award in recognition of his work on truncated distributions. The award is given anually to a professor in the university's College of Arts and Sciences for continuation of a research project already underway.

William N. Creasy, brigadier general and since 1951 in command at the Chemical Corps Research and Engineers Command and the Army Chemical Center, Edgewood, Md., has been promoted to major general and appointed as the Army's chief chemical officer.

James L. Graham, associate professor of psychology at Lehigh University and a member of the staff since 1930, will retire on 30 June.

Maude Pye Hood, acting dean of the School of Home Economics at the University of Georgia, has been given a grant by the Ford Foundation for a 2-yr appointment to the College of Home Economics at Karachi, Pakistan. She will be the senior member of a team of two sent to Karachi to develop home economics work. Her colleague will be **Alma Wood** of Louisiana State University.

Otto Loewi, pharmacologist and physiologist who is a research professor at the New York University College of Medicine, has been elected to the Royal Society of London.

On 22 June **Walter B. Martin** of Norfolk, Va., was installed as the 108th president of the American Medical Association, succeeding **Edward J. McCormick** of Toledo, Ohio.

Friend Lee Mickle, for 35 yr a member of the staff of the Connecticut State Department of Health and at present chief of Laboratory Services and director of the Bureau of Laboratories of that department, is retiring on 30 June. He plans to travel and later to do some consulting work in public health.

Gustavo Molina, former professor of public health administration in Chile, has been appointed chief of the Division of Public Health of the Pan American Sanitary Bureau, Regional Office of the World Health Organization. Dr. Molina has been in charge of the Bureau's professional education branch since last July.

To honor outstanding engineering achievement in the field of agriculture, the American Society of

Agricultural Engineers, on the occasion of its annual dinner held 21 June at the University of Minnesota, awarded the John Deere gold medal to **Raymond Olney** of St. Joseph, Mich., and the Cyrus Hall McCormick gold medal to **Wayne H. Worthington** of Waterloo, Iowa.

John R. Paul, chairman of preventive medicine at Yale University and specialist on the spread of poliomyelitis, infectious hepatitis, and rickettsial disease, has been awarded the Howard Taylor Ricketts medal of the University of Chicago. The Ricketts medal, honoring the late University of Chicago physician who died of typhus in May 1910, is given in recognition of outstanding medical work.

Robert V. Ruhe, research geologist in the soil survey division, U.S. Department of Agriculture, and collaborator at the Iowa Agricultural Experiment Station, has received a grant-in-aid from the Wenner-Gren Foundation for Anthropological Research to conduct geopedological research in Africa, Belgian Congo, Central African Federation, and the Union of South Africa, during the period 12 Aug. 1954 to 14 Jan. 1955. The purpose of Dr. Ruhe's work will be to determine the use of soils in the correlation of erosion surfaces that may prove beneficial in outlining the Pleistocene climatic and landform sequences and the relation of river terraces and changes in lake sizes to those sequences. The establishment of such sequences will facilitate research in archeology. Before proceeding to the African interior, Dr. Ruhe will report on his work of 1951–52 in the Belgian Congo, Uganda, and Ruanda-Urundi, to the 5th International Congress of Soil Science, Leopoldville, Belgian Congo.

J. R. Schramm, professor of botany at the University of Pennsylvania and director of the Morris Arboretum, will be away on sabbatic (and terminal) leave for the year 1954–55. After attending the International Botanical Congress, he will travel in Europe and the Near East.

Education

Twenty faculty members and six graduate students from 24 educational institutions have accepted summer appointments at **Argonne National Laboratory.** The Laboratory, operated by the University of Chicago for the U.S. Atomic Energy Commission, makes such appointments annually to encourage research and to strengthen teaching in fields related to nuclear energy.

The most serious problem in **cancer research** today, says F. Peyton Rous, "is the cleavage which exists between the laboratory and the clinic." Speaking before a group of more than 200 cancer researchers, who met 5–6 April in the new $10,000,000 building of **The University of Texas M. D. Anderson Hospital and Tumor Institute,** just opened in the Texas Medical Center, Dr. Rous called for a closer integration of minds, as well as integration of physical facilities. "It is only now, in a place like the Anderson Hospital and New York's Memorial Center, that they are brought together," he said. "But the cleavage still exists."

Dr. Rous, emeritus member of the department of pathology and bacteriology at the Rockefeller Institute for Medical Research, was in Houston to deliver the Bertner Lecture and to receive the Bertner Foundation Award for his own outstanding contributions to cancer research.

Merrill M. Flood, professor of Industrial Engineering at Columbia University, has been appointed director of the newly-formed **Columbia Institute for Research in the Management of Industrial Production.** The institute's primary purpose is to conduct research in the problems of management of industrial production and specifically into the problems that originate in factories. Its work is of the inter-disciplinary type, including collaboration of such areas at Columbia as psychology, sociology, economics, mathematical statistics, and business management. In addition to project research, the new unit will conduct several conferences each year and will eventually provide for research in the field by Columbia students. Work at the institute will be guided by an advisory committee.

This past winter the administration of teaching and research in **engineering at the University of Pennsylvania** was completely reorganized so as to coordinate and extend the University's activities in these fields. The Towne Scientific School is now divided into four separate schools of chemical, civil, mechanical, and metallurgical engineering, each with its own faculty. Two assistant vice presidents for engineering have been appointed—S. Reid Warren and Arthur N. Hixson—and directors were named to head the four new schools and also the Moore School of Electrical Engineering: Melvin C. Molstad, chemical engineering; Emory F. Stover, civil engineering; Lee N. Gulick, mechanical engineering; Robert M. Brick, metallurgical engineering; and John G. Brainerd, Moore School. All seven administrative officers hold full professorships in engineering at the University and are continuing their teaching work in addition to serving as administrators.

In addition, provision was made for the establishment of an Institute for Cooperative Research to stimulate, coordinate, and manage investigative activities in the engineering field for industry, foundations, and government. All these various engineering units are directed by Carl C. Chambers, vice president in charge of engineering affairs. No physical changes are necessitated by the reorganization. The four new schools were formerly departments of the Towne School and will continue to be housed in the Engineering Building, now to be known as the Towne Building.

Plans are being made to establish the nation's first **psychiatric clinic for adolescents** in the new Mental Hygiene Unit of the University of California at Los Angeles Medical Center. Devoted to juvenile delinquency and other problems of adolescence, the center will include a 24-bed ward in the neuropsychiatric

hospital, special classrooms, and an adolescent outpatient's clinic. Norman Brill will head the neuropsychiatric program.

The adolescent center is one of several divisions in the Mental Hygiene Unit, which will be operated jointly by the State Department of Mental Hygiene and the university. Other divisions include adult and child psychiatry, neurosurgery, and neurology. The neurology division will be concerned with study and treatment of such diseases as epilepsy, multiple sclerosis, muscular dystrophy, and tumors of the central nervous system.

Grants and Fellowships

Eugene P. Odum, professor of zoology at the University of Georgia, and his brother, Howard T. Odum, a member of the University of Florida faculty, will spend the summer at the newly established laboratory on Eniwetok Atoll, near the site of the recent nuclear explosions in the Pacific, on a special assignment for the **Atomic Energy Commission.** They will make basic studies of the biological productivity of coral atolls as a whole, rather than of the direct effects of radiation on individual organisms.

Acting for the American Cancer Society, the Committee on Growth of the National Research Council is accepting applications for grants-in-aid for **cancer research** in the United States. Applications received *before 1 Oct.* will be considered during the winter and grants recommended at that time become effective on 1 July 1955. Investigators now receiving support will be notified individually regarding their applications for renewal.

The Committee feels that an understanding of cancer depends upon a deeper insight into the nature of the growth process, normal and malignant. Therefore, the scope of the present program is broad and includes, in addition to clinical investigations on cancer, fundamental studies in the fields of cellular physiology, morphogenesis, genetics, virology, biochemistry, metabolism, nutrition, cytochemistry, physics, radiobiology, chemotherapy, endocrinology and environmental cancer. Application blanks may be obtained from the Executive Secretary, Committee on Growth, National Research Council, 2101 Constitution Ave., NW, Washington 25, D.C.

The Lederle Laboratories Division, American Cyanamid Company, has announced the following recipients of **Lederle Medical Faculty Awards** for the year 1954:

J. Dempsher, Dept. of Pharmacology, School of Medicine, University of Pennsylvania, 3 yr.
D. W. Fawcett, Dept. of Anatomy, Harvard Medical School, 3 yr.
E. C. Gjessing, Dept. of Biochemistry, University of Vermont, 3 yr.
E. D. Grim, Dept. of Physiology, University of Minnesota, 3 yr.
F. O. Kelsey, Dept. of Pharmacology, University of South Dakota, 3 yr.
R. G. Langdon, Dept. of Physiological Chemistry, Johns Hopkins Medical School, 3 yr.
F. V. Lucas, Dept. of Pathology, University of Rochester, 2 yr.
W. K. Maas, Dept of Pharmacology New York University College of Medicine, 3 yr.
L. M. Marshall, Dept. of Biochemistry, Howard University College of Medicine, 3 yr.
M. L. Moss, Dept. of Anatomy, Columbia University, 2 yr.
G. E. Murphy, Dept. of Pathology, Cornell University Medical College, 3 yr.
S. Shulman, Dept. of Bacteriology and Immunology, University of Buffalo, 3 yr.
J. R. Teabeaut, II, Dept. of Pathology, University of Tennessee, 1 yr.
V. L. van Breeman, Dept. of Anatomy, University of Colorado, 2 yr.

Mary Thornton Page, widow of the late Leigh Page, professor of mathematical physics at Yale University from 1922 until his death in September 1952, has established a fund in memory of her husband to support a yearly prize of $1000 to be given to an outstanding first-year graduate student in the field of physics. This **Leigh Page memorial prize** is one of the two largest ever created at Yale; its first recipient is Loyal Durand, III, of Knoxville, Tenn.

The following scientists were among the 236 recipients of 1-yr fellowships granted by **The Fund for the Advancement of Education** to college and university faculty members in the United States and Hawaii. In addition, the Fund has granted 274 fellowships to high school teachers, including 40 in mathematics and the natural sciences.

J. D. Gómez-Ibáñez, Wesleyan University; chemistry.
B. M. Wheeler, Connecticut College; zoology.
E. P. Clancy, Mount Holyoke College; physics.
C. F. Mosteller, Harvard University; mathematics and statistics.
L. N. Hadley, Jr., Dartmouth College; physics.
G. H. Smith, Rutgers University; psychology.
M. L. Gabriel, Brooklyn College; biology.
E. E. Hanlon, Syracuse University; geography.
R. J. Ordway, New York State Teachers College; natural sciences.
W. G. Clark, Mount Union College; physics and mathematics.
W. Ellis, Oberlin College; mathematics.
E. S. Graham, Kenyon College; chemistry.
W. C. Kelly, University of Pittsburgh; physics.
H. D. Rix, Pennsylvania State University; physics.
C. R. Mitchell, Rhode Island College of Education; mathematics.
R. W. Morse, Brown University; physics.
H. E. Kirkby, Shimer College; natural sciences.
R. J. McCall, De Paul University; psychology.
E. C. Williams, Wabash College; zoology.
A. M. Docken, Luther College; chemistry.
M. F. Smiley, State University of Iowa; mathematics.
H. C. Trimble, Iowa State Teachers College; mathematics.
P. W. Renich, Kansas Wesleyan University; science.
K. MacCorquodale, University of Minnesota; psychology.
T. B. Thomas, Carleton College; zoology.
S. S. Judson, Jr., University of Wisconsin; geology.
J. V. Talacko, Marquette University; mathematics.
O. L. Lacey, University of Alabama; psychology.
B. F. Smith, Spelman College; biology.
W. G. McGavock, Davidson College; mathematics.
J. J. Friauf, Vanderbilt University; biology.
J. F. MacNaughton, University of Houston; psychology.
B. W. Mundy, Virginia Military Institute; chemistry.
G. B. Rossbach, West Virginia Wesleyan College; biology.
M. D. Appleman, University of Southern California; bacteriology.
C. M. Gorman, University of San Francisco; chemistry.
W. E. Pequegnat, Pomona College; zoology.
A. E. Treganza, San Francisco State College; anthropology.
M. B. Turner, San Diego State College; psychology.
R. G. Beidleman, Colorado A & M College; zoology.
W. A. Fischer, Colorado College; geology.
L. M. Stanford, College of Idaho; biology.
G. E. Osborne, University of Utah; pharmacy.

In the Laboratories

The new laboratories, at Bedford, Mass., of the **Air Force Cambridge Research Center** were officially opened on 26 Apr. The center is one of 11 installations under Thomas S. Power, Lt. General and new commander of the USAF Air Research and Development Command, Baltimore, Md., that are engaged in the development of new and improved weapons, weapons systems, and guided missiles.

Don Baxter, Inc., manufacturer of intravenous solutions, blood transfusion containers, and plastic hospital products, has a new two-story research building in Glendale, Calif., adjacent to the company's office and production laboratories. The new structure provides each member of the research staff with an individual, fully equipped laboratory. Other features include spacious conference rooms, a library, development laboratories, a model shop, an animal room, and physical, chemical, functional, bacteriological, and biological testing laboratories. The entire building is sound-conditioned with acoustic tile ceilings. A two-duct air conditioning system is provided with individual controls in each room.

Between 400 and 500 additional workers will be employed at the **General Electric Co.'s Knolls Atomic Research Laboratory** as a result of a projected $13,000,000 expansion program that will increase facilities and personnel by about 50 percent. Construction is under way, and the buildings should be equipped and ready for occupancy within 20 mo. Included among the new additions are a five-story wing for the main laboratory; a $3.7 million laboratory and shop-type structure for the development of metallurgy and ceramic materials and their processing; and a $1.8 million combustion building.

The boards of directors of **Mathieson Chemical Corp. and Olin Industries, Inc.,** recently voted unanimously to submit to their stockholders, at special meetings on 29 June 1954, a proposal to merge the two companies. Mathieson is a leading producer of industrial and agricultural chemicals, petrochemicals, and through its E. R. Squibb & Sons Division, drugs and pharmaceuticals. Its operations are world-wide and include 25 plants in the United States and 16 in foreign countries.

Olin Industries is a large producer of metals and fabricated parts, industrial explosives, military and sporting firearms and ammunition, cellophane, polyethylene, fine specialty papers, forest products, powder-actuated fasteners and tools, and electrical products and maintains a large research staff to develop new and improved products. Olin operates 18 plants, all in the United States.

A $4,500,000 wind tunnel under construction at **North American Aviation, Inc.,** Los Angeles, will be one of the largest in private industry. It will be capable of testing airplane and missile designs at speeds ranging from 400 mi/hr to more than three times the speed of sound.

To more effectively investigate and develop new pharmaceuticals for use by the medical profession, the **Schering Corp.** has created four new divisions: biological and therapeutic research, directed by Edward C. Reifenstein, Jr.; medicinal and pharmaceutical research, directed by S. W. Lee; chemical research and development, directed by E. B. Hershberg; and research services, directed by Bradley Whitman.

The **U.S. Public Health Service's National Cancer Institute** has announced establishment of a **leukemia studies section** in the Laboratory of Biology to be headed by Lloyd W. Law.

Also announced was the appointment of George Hogeboom as head of the cellular biology section of the Laboratory of Biology. Dr. Hogeboom has worked in the laboratory since 1948; he has been head of the cell chemistry unit of the section since 1950.

Ground has been broken for the new $4,000,000 **Wyeth Laboratories** headquarters building on a 27-acre site 12 mi west of Philadelphia. The structure will house the executive and sales offices and research laboratories; it is scheduled for completion in July 1955.

Meetings and Elections

The **American Association of Clinical Chemists** has elected these officers: pres., Monroe E. Freeman, Medical Service Corps of the Department of the Army; v. pres., Otto Schales, Ochsner Clinic, New Orleans; sec., Max M. Friedman, Lebanon Hospital, New York; treas., Louis B. Dotti, St. Luke's Hospital, New York.

The **American Institute of Mining and Metallurgical Engineers** has elected the following officers for 1954–55: pres., Leo F. Reinartz; treas., Gail F. Moulton; sec., Edward H. Robie. Vice presidents are O. B. J. Fraser, J. B. Morrow, L. E. Elkins, A. B. Kinzel, T. B. Counselman, and Harold Decker.

At the summer meeting of the **American Physical Society,** University of Minnesota, 28–30 June, there will be 31 invited papers: on surface physics and domain formation, by G. K. Wehner, W. J. Merz, and E. A. Coomes; on nuclear radii, by R. W. Pidd and D. J. Zaffarano; on ion and electron dynamics, and luminescence, by L. B. Leder, J. P. Blewett, and L. M. Field; on astronomical subjects, by W. A. Hiltner, W. J. Luyten, T. L. Collins, and F. Graham Smith; on electronic conduction in solids, by L. Apker and R. H. Bube; on theoretical physics, including quantum electrodynamics, by W. B. Cheston, J. M. Jauch, and F. Rohrlich; on gaseous electronics, by R. N. Varney, W. P. Allis, and M. A. Biondi; on cosmic-ray physics, by Phyllis Freier, Nahmin Horwitz, Leland Bohl, and H. S. Bridge; on electron and nuclear emission and ejection phenomena, by A. J. Dekker, L. S. Nergaard, and J. A. Krumhansl, Jr.; on nuclear accelerators, by N. F. Ramsey, R. G. Herb, E. J. Lofgren, and Lyle

W. Smith. Some 112 10-min contributed papers are distributed among 13 sessions.

Officers of the **American Psychosomatic Society** for 1954 are: pres., Lawrence S. Kubie; pres.-elect, Stanley Cobb; sec.-treas., Theodore Lidz.

The **Bicentennial Conference of the Columbia University College of Pharmacy** will be held at the university 14–15 Oct. in honor of the bicentennial of the university and the 125th anniversary of the College of Pharmacy. The theme of the conference is "Pharmacy and the conquest of disease." George W. Merck, chairman of the board of Merck & Co., Inc., is chairman of the conference's national committee.

The **11th Brazilian Congress of Chemistry** to be held in São Paulo, 4–10 July, is the second organized by the Associacão Brasileira de Química, the Association which since 1951 has united the two chemical societies that formerly existed in Brazil. The meeting takes place in São Paulo this year because the city is commemorating its 400th anniversary. In addition to the presentation of papers in all fields of chemistry, there will be three symposiums: (i) "Special methods in analytical chemistry"; (ii) "Basic raw materials for the chemical industry"; (iii) "Present applications of organic chemistry."

"Critical objectives in graduate study" was the subject of a round-table discussion held on 18 May at the Rice Institute. The meeting was opened by Winfred O. Milligan, Rice Institute, and the panel leaders included H. H. Meier, Humble Oil & Refining Co.; W. Gordon Whaley, University of Texas; M. King Hubbert, Shell Oil Co.; William V. E. Doering, Yale University; and F. H. Westheimer, Harvard University. Carey Croneis, Rice Institute, served as moderator. The significance of graduate research was emphasized not only for advanced students planning a specific research career, but also for others who may apply the results of research in various industrial fields.

The **International Association of Milk and Food Sanitarians** has elected these officers: pres., John D. Faulkner, Washington, D.C.; pres.-elect, I. E. Parkin, State College, Pa.; 1st v. pres., Ivan Van Nortwick, Lawrence, Kan.; 2nd v. pres., Harold S. Adams, Indianapolis, Ind.; sec.-treas., H. H. Wilkowske, Gainesville, Fla.

An **International Symposium on the Hypophyseal Growth Hormone,** sponsored by the Henry Ford Hospital and the Edsel B. Ford Institute for Medical Research, will be held in the Henry Ford Hospital, Detroit 27–29 Oct. Formal presentations and discussions will cover bioassay, preparation, and physicochemical properties of growth hormone; effects of growth hormone on certain structures such as the mammary gland, skeletal system, connective tissue, Islets of Langerhans, kidneys, gastrointestinal tract, and tissue cultures; growth hormone and energy sources; the effect of growth hormone on cellular systems; the influence of growth hormone on lactation; and its metabolic effects in man. Interested persons should write the Program Committee, Henry Ford Hospital, Detroit 2, Mich.

Officers of the **Oklahoma Academy of Science** for 1954 are: pres., A. N. Murray, Tulsa University; v. pres. and sec.-treas., Ralph E. Olson, University of Oklahoma; assistant sec.-treas., D. E. Howell, Oklahoma A. & M. College. The permanent secretary is A. O. Weese, University of Oklahoma.

The 12th annual **Pittsburgh Diffraction Conference** will be held at the Mellon Institute 3–5 Nov. This will be a joint meeting with the **American Crystallographic Association.** Technical sessions are being arranged on "Instrumentation and methods," "Metals," "Neutron diffraction," "Small-angle scattering," and "Silicates and related structures." Papers on general diffraction subjects will also be accepted.

Contributed papers will be considered in the order in which they are received. Titles should be submitted to Prof. G. A. Jeffrey, University of Pittsburgh, Pittsburgh 13, Pa., *before 1 Sept.* Abstracts are due *by 20 Sept.* For further information write to Dr. P. K. Koh, Allegheny Ludlum Research Laboratories, Alabama Ave., Brackenridge, Pa.

The **Society for the Advancement of Criminology** has elected the following officers: pres., William Dienstein, Fresno State College, Fresno, Calif.; sec.-treas., Lowell W. Bradford, San Jose State College, Calif. Vice presidents are Fred Fitzgerald, City College of San Francisco; Arthur F. Brandstatter, Michigan State College; Donal E. J. MacNamara, New York University.

Representatives from women's colleges and from industries employing women met for a conference on **"The role of the women's colleges in the physical sciences"** held at Bryn Mawr College, 17–18 June. The meeting was under the chairmanship of Walter C. Michels of Bryn Mawr.

New officers of the **Virginia Academy of Science** are: pres., Irving G. Foster, Virginia Military Institute; sec.-treas. emeritus, E. C. L. Miller; sec.-treas., Foley F. Smith, P.O. Box 1420, Richmond 11; pres.-elect, Walter S. Flory, Blandy Experimental Farm, Boyce.

Miscellaneous

The Medical Faculty, University of Zagreb, Zagreb, Yugoslavia, has commenced publication of a journal, ***Acta Facultatis Medicae Zagrebensis,*** that will appear three times a year. It covers all medical branches, both clinical and theoretical. Articles are followed by a summary in one of the world languages.

Beginning in May the **American Geological Institute's *newsletter*** became an 8-page, 3-column newspaper, and starting with the September issue, it will

be mailed to everyone whose name and address appears in the Earth Sciences Section of the National Register of Scientific and Technical Personnel.

Since the announcement last winter of the publication of **"Basic Care of Experimental Animals,"** a manual especially prepared for the men and women who take care of laboratory animals, requests have been received from laboratories throughout the United States and Canada, and 2124 free copies have been distributed. Copies are still available from the Animal Welfare Institute, 350 Fifth Ave., New York 1.

The following **chemicals** are wanted by the Registry of Rare Chemicals, Armour Research Foundation of Illinois Institute of Technology, 35 W. 33 St., Chicago, Ill.: Silicon disulfide; potassium perselenate; octahydrophenanthrene; 6-amino-8-hydroxyquinoline; 4-methyl-1,4-heptanediol; 2-aminonaphthalene-4-sulfonic acid; quinquephenyl; cyclohexiimid; 3-methylthiophene; glycidic acid; 2,4-diamino-5-hydroxyphenol; benzophenone-2,2′-dicarboxylic acid; oxine-5-sulfonic acid; 2-hydroxynicotinic acid; D-cysteine; ptylin; scyllitol; esculetin; sinigrin.

The American Museum of Natural History recently opened an exhibit, **"Fishes Through Time,"** that explains 400 million years of fish history. The new permanent exhibit was constructed under the supervision of Bobb Schaeffer, associate curator of fossil fishes.

The following articles are featured in the July issue of ***The Scientific Monthly***: "Parapsychology and dualism," Roland Walker; "The numerical relationships between phytophagous insects and their hosts," S. W. Frost; "Science and ideology," Adolf Grünbaum; "On Coriolis force and bird navigation," William J. Beecher; "Science and common sense," P. W. Bridgman; "Education in the sciences," Robert Boyce Green; "Three young naturalists afield: the first expedition of Hyatt, Shaler, and Verrill," Ralph W. Dexter; "Scientific research in Antarctica," Vivian E. Fuchs. Also featured is an abridged version of the late Walter B. Cannon's outstanding AAAS presidential address, "The body physiologic and the body politic," which was published originally in *Science* **93**, 1 (1941).

Necrology

Joseph H. Abraham, 83, author and former professor of otolaryngology at Polyclinic Hospital and Postgraduate Medical School, New York City, 3 June; **Mahlon Ashford,** 73, former chief surgeon of the Panama Department, Army Medical Corps, and retired secretary of the New York Academy of Medicine, Washington, D.C., 5 June; **Kenneth N. Atkins,** 77, professor of bacteriology at Dartmouth Medical School, Hanover, N.H., 20 May; **Ernest B. Benger,** 68, retired authority on synthetic fibers and films for E. I. du Pont de Nemours, Wilmington, Del., 27 May; **Arthur J. Clark,** 73, professor emeritus of chemistry at Michigan State College, East Lansing, 2 June; **Mabel Colcord,** 81, retired chief of entomological work at the Department of Agricultural library, Washington, D.C., 4 June; **Virgil H. Cornell,** 63, former head of the Pathology Department, Walter Reed Hospital, Washington, D.C., 3 June; **William S. Fones,** 33, editor and research chemist at the National Cancer Institute, Bethesda, Md., 11 May; **A. F. Greaves-Walker,** 73, author, editor, and retired head of the Department of Ceramic Engineering at North Carolina State College, Raleigh, 18 April; **Charles R. Heed,** 74, former clinical professor of ophthalmology at Jefferson Medical College, Philadelphia, Pa., 23 May; **Walter Heikel,** 76, author and agricultural authority, Paraguay, 21 May; **John Homans,** 76, author and clinical professor emeritus at the Harvard Medical School, Boston, Mass., 7 June; **Lloyd A. Jones,** 73, retired head of the physics division at the Eastman Kodak research laboratory, Rochester, N.Y., 15 May.

Laurence La Forge, 82, retired consulting geologist and geological engineer, and former professor at Tufts College, Medford, Mass., 29 May; **Fritz O. Laquer,** 65, author, chemical researcher, and professor of biochemistry at Temple University School of Pharmacy, Philadelphia, Pa., 29 May; **Fred V. Larkin,** 71, professor emeritus of mechanical engineering at Lehigh University, Bethlehem, Pa., 23 May; **Edwin P. Lehman,** 65, author, past president of the American Cancer Society, and retired professor of surgery and gynecology at the University of Virginia, Charlottesville, 27 May; **Oliver I. Lewis,** 51, electronics researcher and chief engineer for the Engineering and Technical Division, U.S. Army Signal Corps, Washington, D.C., 18 May; **Robert V. Martin,** 40, orthopedist, founder and director of the Nassau County Cerebral Palsy Center at Roosevelt, N.Y., 18 May; **Henry Minsky,** 58, author, ophthalmic surgeon and researcher, New York City, 23 May; **Ilia E. Mouromsteff,** 72, research engineer and professor of physics at Upsala College, East Orange, N.J., 18 May; **Clarence P. Oberndorf,** 72, author, editor, neurologist, psychoanalyst, and former clinical professor of psychiatry at Columbia University, New York City, 30 May; **Thomas A. Pendleton,** 68, author and retired chief topographic engineer for the U.S. Geological Survey, Washington, D.C., 28 May; **Fred W. Rankin,** 67, president of the American College of Surgeons, past president of the American Medical Association, former professor, author, and authority on cancer of the colon, Lexington, Ky., 22 May; **Henry S. Rawdon,** 73, author and retired chief of the Metallurgy Division of the National Bureau of Standards, Washington, D.C., 14 May; **Nathan Sulzberger,** 79, chemist and inventor, New York City, 5 June; **Augustus B. Wadsworth,** 81, past president of the Association of Pathologists and Bacteriologists, author, former professor, and retired director of laboratories and research for the New York State Department of Health, New York City, 1 June; **Paul C. Whitney,** 71, hydrographic and geodetic engineer, author, and retired supervisor of the Southeastern District of the Coast and Geodetic Survey, Washington, D.C., 9 June.

Book Reviews

Projective Geometry and Projective Metrics. Herbert Busemann and Paul J. Kelly. Academic Press, New York, 1953. 332 pp. Illus. $6.

It is not often that a book combining excellent material, clarity of exposition, and graceful style makes its appearance. This is such a book. That the authors are consummate masters of the subject goes without saying, but they have also shown a deep sense of esthetic value and appreciation of the beauty of geometry. They point out with some sadness—with which I am deeply sympathetic—that classical geometry has fallen upon hard times, probably because other mathematical disciplines have become more attractive and because in our search for generality and abstractness we have lost interest in the beauties of various geometric constructs.

The book is a happy combination of analytic and synthetic methods. Those of us who cut our geometric teeth on Veblen and Young might wish for a little more rigor and axiomatization, but one must recognize that the choice the authors made was deliberate since the book is not intended for a highly sophisticated audience. Starting with the geometry of the projective plane, the authors develop affine and equiaffine geometries, which necessitates the introduction of such notions as groups homeomorphisms and isomorphisms. An abstract metric is then introduced and its various specializations lead quite far afield to such geometries as those of Hilbert and of Minkowski. The book concludes with three-dimensional projective geometry where various more sophisticated notions are either mentioned or fully discussed.

One might wish that the authors had included some work of Von Staudt, or a little of the more recent work on distance geometries. But the book is rich enough, so that if any book deserves to live this one does.

M. S. Knebelman
Department of Mathematics, State College of Washington

Robert Grosseteste and the Origins of Experimental Science, 1100–1700. A. C. Crombie, Oxford Univ. Press, New York, 1953. 369 pp. Illus. + plates. $7.

Important technological developments were occurring in Europe from about the 9th century on, and knowledge of ancient Greek science began to be acquired on a large scale in the 12th century. It is both a presupposition and a conclusion of Crombie's book that the consequent fusion of these two traditions produced the sorts of attitudes and inquiries that we call modern science and that it had recognizably done so by the 13th century.

Focusing initially upon the scientific work of Grosseteste, the author then proceeds to other members of the Oxford School in the 13th and 14th centuries, and to their influence upon European science, with particular attention to certain aspects of the study of color and light. Sufficient material is assembled to enable Professor Crombie to show the influence, particularly methodological, on the work of the major physicists of the 17th century.

This book is an important contribution to the history of science in the 12th, 13th, and 14th centuries. It also should be of major interest to those concerned with the origins and nature of modern scientific thought.

Duane H. D. Roller
Harvard University

The Challenge of Man's Future. Harrison Brown. Viking Press, New York, 1954. xii + 290 pp. Illus. $3.75.

Harrison Brown, the author of this volume, is a geochemist. In 1947 he received the American Association for the Advancement of Science annual award and, in 1952, the American Chemical Society award in pure chemistry.

He presents a picture of the balance of nature on this globe as it was before the advent of man, during early and more recent historical times, and after the development of modern technology. A moderately fertile wild region of 10,000 mi^2 provided enough food for about 5000 persons who lived solely by collecting wild plants and animals. By a slow and fluctuating process and then recently with a rapid spurt the total population of the globe has been modified as the centuries have passed. Through the years, there has been a close relationship between population and food production or importation in various countries. In England, for example, from 1700 to 1840, the birth rate fluctuated but the death rate gradually declined. From 1890 to 1940, however, the rise in total population in England was startling. He points to the danger of the exhaustion of fossil fuels and other resources in relation to the increase of population in industrial nations.

Even today, two-thirds of the world's population lives under conditions in which both birth rates and death rates are high and food production is insufficient even in good times to provide adequate nourishment for everyone. For two or three thousand years prior to 1850, India probably had a stable population of between 50 and 100 million persons. The tremendous rise in the population of this subcontinent has resulted from the introduction of Western ideas and ideals and an increased importation of foods. Since 1940, for example, the population of the Indian subcontinent has been increasing at a rate of about 5 million persons per year. Over 90 percent of the total man hours worked in India are now devoted to the production, handling, and transportation of food.

In conclusion, the author points to the difficulties that lie ahead for the human race. He does suggest that the possibility cannot be excluded that a balance between numbers of human beings and food and

energy may yet be found. He suggests, "Just as we have rules designed to keep us from killing one another with our automobiles, so there must be rules that keep us from killing one another with our fluctuating breeding habits and with our lack of attention to the soundness of our individual genetic stock."

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Dielectric Aerials. D. G. Kiely Methuen, London; Wiley, New York, 1953. xii + 132 pp. Illus. $2.

Dielectric aerials, also called "polyrod antennas," may be thought of as wave guides from which energy "leaks" out the sides and the resulting interference sets up a radiation pattern, usually with end-fire directivity. The dielectric antenna may have the form of a rod, a tube, or a horn. It has been used mainly where a compact array is desired or metal is not wanted.

The author states that "no complete theory of the mechanism of the radiation of dielectric rods exists at present" and even less work has been reported on tubes and horns. After a chapter on wave propagation along dielectric rods, three methods are presented that have been used as a theoretical basis for the observed behavior of polyrod antennas. The first utilizes the Huyghens principle and elementary ray theory; the second considers the rod to be a type of lens; the third, and favored, method is based upon a set of fictitious electric and magnetic surface currents following Schelkunoff. After developing the three methods and comparing results for pattern calculations, the author deals briefly with band width, losses, and practical applications.

The analysis of tubular structures and horns is more complicated mathematically and less practical experience has been reported. There is a good summary of the material available.

Minor differences of notation and terminology (such as the Continental usage of delta for the Laplacian) should cause no difficulty. Perspective drawings of field configurations would have been helpful at several points. The mks system of units is used. The bibliography contains 29 items.

This book conforms to the usual high standards of the "Monographs on Physical Subjects" and should be a welcome and useful addition to the literature on antennas and radiation.

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Solubilities of Inorganic and Organic Compounds: A Compilation of Solubility Data from the Periodical Literature. Supplement to ed. 3. Atherton Seidell and William F. Linke. Van Nostrand, New York, 1952. 1254 pp. $12.50.

This supplementary volume to the third edition of *Solubilities* contains literature data published in the years 1939–49, inclusive. Ownership of the book and responsibility for publication have been assumed by the American Chemical Society.

This issue contains four parts. The inorganic section, compiled by Seidell, is arranged in alphabetical order according to the elements, and contains 567 pages.

The organic part, compiled by Linke, is made up of 252 pages. The compounds are arranged according to increasing number of carbon atoms in the molecular formula. Although in a compilation of this kind some errors are bound to occur, it should be emphasized that the naming of a number of carbon compounds does not comply with the adopted rules. Thus, amines such as dimethylamine and ethylamine are expressed in two words, as are compounds such as hexachlorobenzene, trinitroresorcinol, and many others. β-Hydroxypropionic acid is incorrectly designated on page 608 as "β-Oxy Propionic Acid." 2-Bromopropionic acid is listed as "Bromo Propionic Acid," which is ambiguous. On page 609, 1-propanesulfonamide is incorrectly listed as "Propane-1 Sulfamide," and on page 654 "p-Nitro Hydroquinone" should read *o*-nitrohydroquinone. On page 603, the structural formula for propargyl alcohol contains a double bond instead of a triple bond, and on page 701, acetophenone is misspelled.

The third part contains a valuable 180-page compilation by Dr. Francis, of Socony-Vacuum Oil Co., of ternary aqueous and nonaqueous systems and also five pages of quaternary aqueous and nonaqueous systems.

The fourth part is a review, based on 142 references, by Dr. Bates, of the National Bureau of Standards, entitled "Recent contributions to the theory of electrolyte solubility."

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New Books

The Western End of Lake Erie and its Ecology. Thomas H. Langlois. J. W. Edwards, Ann Arbor, Mich., 1954. xx + 479 pp. Illus. $10.

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Dynamics of Growth Processes. L. M. Kozloff *et al.* Edgar J. Boell, Ed. Princeton Univ. Press, Princeton, N.J., 1954. vii + 304 pp. Illus. + plates. $7.50.

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(*Continued on page 12A*)

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(*Continued on page 12A*)

Technical Papers

The Primary Radical Yield in Irradiated Water

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Intensive study of the reactions induced in various aqueous systems by ionizing radiation has led to estimates of the number of water molecules decomposed to form radicals by 100 ev of energy absorbed G_R. These estimates fall into two groups (*1*), a low group ($G_R \sim 3$–5) and a high group ($G_R \sim 11$–13). The low values are derived from the formic acid-oxygen (*4*), the hydrogen-oxygen (*3*), and the ferrous ion (*4–6*) systems; the high values arise from the ceric ion (*2, 7*), dichromate ion (*8*), and hydrogen peroxide (*9*) systems. Other work in this laboratory has provided evidence in favor of a high value for G_R.

The existence of these two groups of values for G_R suggests that solutes may be divided into two classes possessing widely differing reactivity toward the free radicals H and OH. It is known, however, that the decomposition yields of the two solutes used by Hart —formic acid and ferrous ion—are constant over wide concentration regions. This has been taken to imply that they react with all the radicals formed.

It is here postulated that the absorption of ionizing radiation in water gives rise to two groups of radicals, one group being "available" only to the most reactive of solutes. The constant yield obtained with the ferrous system at varying concentrations is then ascribed to the reaction of the ferrous ion with all the radicals of the "universally available" group but with none of those of the second, less readily available group. It is postulated that most solutes, whatever their concentration, do not react with this second group of radicals, which disappear entirely by recombination, to form H_2O and perhaps H_2 and H_2O_2.

The G_R values of 3–5 for the low group and 11–13 for the high group suggest that the radicals of the first, universally available group are derived from ions (it is expected that 3 or 4 ion-pairs will be formed in water by the absorption of 100 ev of energy) while radicals of the second group are formed from excited water molecules. It would then be expected that the radicals of the second group would be less readily available for reaction with the solute, since an H atom and an OH radical are formed in close proximity and will rapidly recombine, unless the solute can react with one or the other, or both, before this occurs. It is significant that the high G_R values have been obtained with substrates of exceptional reactivity, such as hydrogen peroxide. Thus the ceric and dichromate ions are powerful oxidizing agents ($E = -1.61$ and -1.35 v, respectively).

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These postulates may be used to explain some results obtained by Dale and his co-workers. It was shown (*10*) that the inactivation of the enzyme carboxypeptidase (C.P.) was independent of its concentration, except at very low concentrations, and this was interpreted as indicating that all the radicals reacted with the enzyme. Protection experiments then showed that, for example, thiourea was an excellent protector for C.P. (*11*), and this was thought to imply that thiourea also reacted extremely efficiently with the radicals formed by the irradiation of water. However, it was found that the liberation of sulfur from thiourea (*12*) followed a course similar to that for the deamination of glycine—this behavior having been previously interpreted as being due to the recombination of radicals. Thus, by two criterions (protection and the relatively high decomposition yield) thiourea is very radiosensitive, whereas by a third criterion (the shape of the yield versus the logarithm of the concentration curve) it reacts inefficiently with radicals.

Now it is reasonable to suppose that, in any division of solutes into two classes, the members of one class reacting almost completely and the members of the other reacting to a negligible extent with radicals formed from excited water molecules, there will be an intermediate class, the members of which will react more or less efficiently with such radicals, depending on the solute concentration. It is suggested that thiourea is a member of this class. It would then be expected, as was found, that the yield (molecules of solute destroyed or molecules of a particular product formed per 100 ev) would rise steadily with solute concentration as more and more of the radicals arising from excited water molecules react with thiourea, the latter reacting completely, even at low concentrations, with the radicals formed from ions. It would be predicted also that thiourea reacts more efficiently with radicals than, say, formic acid, and this is shown to be so by protection experiments (*11, 13*).

Three other reactions exhibit a steadily increasing yield with increasing solute concentration (*14*), namely, the radiolysis of trypsin and the deaminations of glycine and serine. The ammonia yields for the latter two reactions are 9 for a 20-percent glycine solution and 12.6 for a 5-percent serine solution. The somewhat different chemical natures of these two amino acids, together with the similarity of the yields obtained at the highest feasible concentrations, make it likely that chain reactions—the alternative explanation of the high yields, put forward by Dale (*15*)—do not occur. If this is so and if the reactions are brought about by H or by OH, but not by both, an ultimate G_R value of 9–13 is indicated. Clearly this is a lower limit, since the maximum yield may not be attainable because of the limited solubility of these compounds. However, it is significant that the yield for the serine deamination tends to become constant at the very

highest feasible solute concentration (*16*), whereas for glycine the yield is still rising when the solubility limit is reached.

Stein and Weiss (*17*) found slightly lower yields for the deamination of glycine and, because of the unchanged yields in the presence of hydrogen or oxygen, considered that the radicals H, OH, and HO_2 were equally efficient in the deamination reaction. Such experiments are always open to the alternative interpretation that the substrate reacts so rapidly with the initially formed free radicals that the latter are not converted to other species by reaction with the added gas.

The fact that glycine is a poor protector for alloxazinadenine dinucleotide (*18*) suggests that these two solutes react with different entities arising from the irradiation of water. This lends support to the view that glycine reacts with H or OH but not with both.

A further phenomenon observed by Dale *et al.* (*13, 19*) in the study of protection phenomena is that of the "changing quotient." It was found that the efficiency of the protecting agent decreased as its concentration was increased. This was explained as being due to the inactivation of an enzyme (C.P.) molecule by a protector molecule previously "activated" by reaction with a radical. It is significant that all the substances for which the phenomenon was observed, namely, glucose, thiourea, sodium formate, dimethyl urea, and dimethyl thiourea, are known from protection experiments to react very efficiently with the radicals that deactivate C.P. (*13, 19*). If the concept of the formation of two groups of radicals in irradiated water is accepted, the explanation of the changing quotient must be modified to take into account the greater number of activated protector molecules present in the solution as the concentration of the protector is increased and it reacts with an ever-increasing proportion of the initially formed free radicals.

The validity or otherwise of the hypothesis here presented may be tested experimentally by measurements of the *G* values for the destruction of simple molecules over the greatest possible concentration range. Using radioactive isotopes, it is possible to make such experiments, measuring the disappearance of the substrate and not merely the appearance of a particular product.

I wish to thank F. S. Dainton for helpful discussions on these topics.

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Three-Dimensional Movies without Special Equipment

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There follows a method for putting a binocular feeling of depth into the viewing of an ordinary single-strip moving picture without the use of any complicated or special equipment. Some related observations on a relevant class of physiological phenomena are also included.

A well-known technique for obtaining two pictures of an object from slightly different directions is to rotate slightly the object between exposures (for example, tilt a microscope slide by placing a hair under one side); a stereo pair is thus obtained. This idea has been extended to moving pictures by placing the object on a rotating table (*1*) and taking movies as it rotates through two complete revolutions. This long film is cut in half, and the two resulting filmstrips are shifted in phase between corresponding views by a few frames before simultaneous projection through two projectors. For x-ray movies, the system has been modified (*2*) by a projector that simultaneously projects frames No. 1 and 3, then 2 and 4, and so forth, of a single movie of the rotating subject. (The images in both of the foregoing cases are channeled to the proper eye, for example, with polaroid.) There is another method based upon a physiological effect that allows a person, during ordinary single projection, to see a delayed or previous image in one eye while the other eye sees the present image; this can be used to see depth in any ordinary moving picture that contains sufficient motion.

The time delay between the viewing of a scene and the arrival of the impression in the brain depends on the brightness of the scene, the time being a decreasing function of brightness. Thus, if a person views a pendulum from a direction perpendicular to the plane of swing and places a neutral filter before one eye, the bob will appear to swing in an ellipse, since that eye is supplying an image of a previous position which fuses with the other image to give a resultant position in front of or behind the plane of swing. Such effects are often associated with the name Pulfrich (*3*). A monocular demonstration can be given in a darkened room, using a cigarette with a glowing tip (brighter

than the body of the cigarette). If the cigarette is shaken up and down, the tip will appear to separate itself from the body and dance up and down separately, being 180° out of phase at certain frequencies. Shaking the cigarette longitudinally will cause an apparent periodic change in length. The existence of the effect apparently indicates a threshold in the visual process that is more quickly reached by a large amplitude transient than by a small one.

Thus, to introduce an apparent retinal disparity in a movie of a rotating object, a person need only cover one eye with a neutral filter. Translation will also bring objects out from the background and shift one's angle of view to give depth. Owing to the color-sensitive transient build-up of retinal response, it might be possible to equalize approximately intensities with different colored filters before the two eyes and still have the effect (cf. Fechner Colors, for example, the Benham Top) while viewing monochrome movies. A red filter might be considered to dark adapt one eye (*4, 5*) alone. If the wrong eye is covered, for the existing direction of motion, an unfamiliar scene can appear turned inside out (pseudoscopy). In terms of the filter density, one can calculate the proper angular velocity that the body must have in order to give a normal effective interocular separation (realistic depth). For example, if the difference in time delay from the two eyes is 0.025 sec and the object is 12 ft away from the camera, it should be turned at about 1 rev in 8 sec. Objects in the scene that are turning faster will have their structure magnified in deepness, and vice versa. Circling by the camera can also augment or produce this effect. Apparent depth is inversely proportional to camera distance if the latter is not constant. A darker filter would be appropriate with slower turning, or with slow-motion projection.

It might be noted that the time difference over a given scene is probably not exactly constant, because of a lack of linearity in the dependence of time delay on apparent brightness, but this does not noticeably distort depth. In fact, if the ambient illumination in the swinging-pendulum experiment is altered, the path seems relatively unchanged, thus indicating a reasonable degree of linearity over the range. The fact that the system works indicates that this dependence applies "point by point" within one field of view. Probably these time delays are too short to be effective for movies in general, but in experimental situations the method is convenient. To transmit a 3D television image by this means, it might be better to follow the receiver by a separate cathode-ray tube for each eye and have one tube receive its signal via a delay line. Unlike other systems, band width need not be doubled (just as the previous did not require twice as much film).

A variable density goggle would allow the performance of inexpensive experiments in continuously variable effective ocular separation. It can be observed that whenever a person places a filter before one eye while watching a rotating real object directly, he varies his effective interocular distance. An easy way to demonstrate the movie effect is to watch, with one eye filtered, a ground-glass camera image of an object on a low-speed phonograph turntable. Three-dimensional or depthy shadows can be cast on a flat wall by rotating an object before a point source of light and viewing the shadow in this manner. (In the case of the aforementioned pendulum, it is obvious that the shadow will jump through and off the wall—that is, travel along the path that the pendulum itself would appear to follow). An interchange of filter position will alter the apparent sense of rotation. Without a filter (the density range 0.3 to 1.0 is suitable), a rotating shadow is completely ambiguous. The foregoing method not only is a way to put true binocular "3D" into many single movies (colored or monochrome) by a simple subsequent process, but it exemplifies quite a general method for coding and decoding two channels of certain types of information into one by a form of repetitious time-modulation.

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February 17, 1954.

Incorporation of C^{14} into Various Carbohydrates of Tobacco Leaves after Different Periods of Photosynthesis in $C^{14}O_2$*

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In the numerous recent studies on the path of carbon during photosynthesis, attention has been paid mainly to various soluble compounds, while the role of starch has been neglected. Moreover, in an attempt to find the first compound into which carbon is incorporated, the tendency has been to cut down the time of photosynthesis to as short a period as possible. It appeared desirable, therefore, to follow incorporation of carbon from CO_2 in a starch-producing plant and to extend the observed duration of photosynthesis to several hours. The present experiments were performed with this object in mind.

Nicotiana tabacum plants (variety Connecticut seed leaf) were placed in darkness for 8 hr to deplete their starch content. Then after 2 hr of illumination a large number of 1-in. leaf disks were punched and strung on 10 nylon strings, 10 disks per string. The disks were placed on wet blotting paper at the botton of an 8-liter desiccator, where according to preliminary tests each disk received a constant supply of water.

* This study was made with financial assistance from the National Research Council of Canada and the Charles F. Kettering Foundation.

Table 1. Total activities of starch and sugars isolated from tobacco leaves after different periods of photosynthesis in $C^{14}O_2$.

Feeding time* (min)	Total activity (10^3 counts/min)	
	Sucrose, glucose, and fructose	Starch
20	0	0
1	0	3.48
2½	0	40.5
5	176	306
10	633	642
15	1,730	Sample lost
30	4,290	2,140
60	8,410	4,680
180	15,500	30,000
360	51,900	165,000

* The 20-min feeding period took place in the dark; all other feeding periods were in light.

After 15 min in darkness the desiccator was filled with 5-percent $C^{14}O_2$ and the dark period was continued for another 20 min.

At the end of this time a sample, consisting of one string of 10 leaf disks, was removed and killed in boiling 80-percent ethanol. The photosynthetic chamber was then illuminated, and successive samples were taken at the time intervals noted in Table 1.

The glucose, fructose, and sucrose from the ethanol extracts were isolated by paper partition chromatography, and after radioautography their total and specific activities were determined as described elsewhere (*1*).

The starch in the ethanol insoluble residue was extracted with perchloric acid, precipitated with iodine, and purified, and its total and specific activities were determined (*1*). Two experiments were carried out with 1 and 3 millicuries of C^{14}, respectively. Since the results of both were essentially the same, only those for the 3-millicurie feeding are given.

Table 1 shows that activity appeared in the "starch" fraction before it did in sugars. Since the technique used did not separate starch from the dextrins, which might be present, the activity observed in this fraction could really be in dextrins. Gibbs observed that in illuminated sunflower leaves uniformly labeled glucose appeared in dextrins before it did in sucrose (*2*). However, whether this activity is in dextrins or in starch, C^{14} appears in a polysaccharide before it does in sucrose, glucose, or fructose.

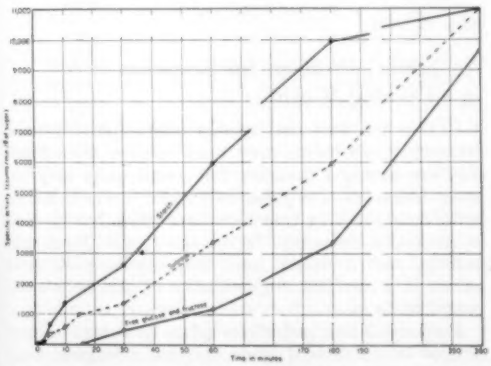

Fig. 1. Specific activities (counts/min) of starch (top curve), sucrose (middle curve), free glucose and fructose (bottom curve) isolated from tobacco leaves after different periods (min) of photosynthesis of $C^{14}O_2$.

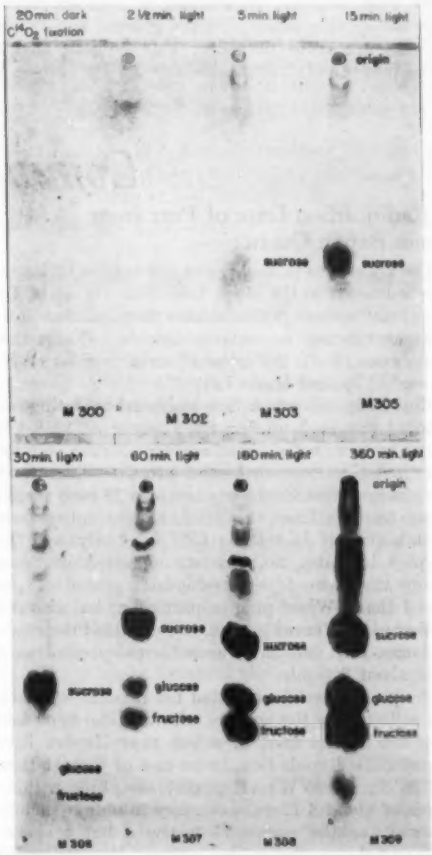

Fig. 2. Incorporation of C^{14} into sugars after different periods (min) of photosynthesis in $C^{14}O_2$.

If the total activity in the "starch" fraction is compared with that of the sucrose, glucose, and fructose, one can see that at first it is higher in the starch. After 30 min more, activity is higher in the sugar fraction; but after 3 hr of photosynthesis the starch fraction is again higher.

Figure 1 shows that up to 3 hr of photosynthesis the specific activity of the starch is consistently higher than that of sugars, while at the end of 6 hr all the specific activities are about equal. At this point the

specific activities of the carbon in the starch and sugars are approximately equal to that of the carbon fed.

Figure 2 shows the radioautographs obtained from the ethanol extracts. The activity first appeared in sucrose and only later in fructose and glucose. This is in agreement with the results obtained by Calvin and Benson (*3*). The fructose and glucose are in approximately equal amounts and contain about the same total activity. Hydrolysis of sucrose revealed that the specific activity of the glucose and fructose moieties are about the same. This suggests that the free glucose and fructose are formed by sucrose hydrolysis. It is interesting to note that in every case the fructose was as abundant as the glucose.

From the results obtained, it is evident that in tobacco leaves during photosynthesis, carbon from CO_2 appears in the "starch" fraction before it does in sugars. This observation brings back to us an old idea of Sachs, that starch is the first visible product of photosynthesis.

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January 25, 1954.

Communications

A Radiocarbon Date of Peat from James Bay in Quebec

The authors have made extensive studies of bog and lake sediments in the Mont Tremblant region of Quebec (*1*). Previous pollen studies were carried out by the senior author in southern Quebec (*2*), the Great Lakes area (*3–5*), the eastern coastal regions of New Jersey (*6, 7*), and Maine (*8*).

The study to which the radiocarbon-dating contributed was made during the summer of 1953 when the authors, with the aid of airplane service, extended their investigations northward into the wilderness regions near James Bay. They sampled 19 bogs forming a line transect from the St. Lawrence valley to the north branch of Jack River (52°N). Analysis of these samples indicates that forests migrated northward during the warm-dry (xerothermic) period of postglacial times. White pine in particular, but also some southern broadleaved genera, had extended their range to James Bay, but have since been depressed southward about 350 mi.

The peat material submitted for radiocarbon dating was collected by the authors with a Hiller-type borer from the bottom level of a bog near Rupert River, Smoky Hills Rapids Bog, 18 mi east of Rupert House (51°28′N; 78°45′W). Repeated sampling within a radius of about 4 ft was necessary to obtain sufficient material for the carbon-14 analysis, but the sharp contrast between the earliest organic deposits and the rock flour bottom sediments facilitated the securing of these multiple samples at a uniform level.

The samples thus obtained were submitted to the Lamont Geological Observatory for carbon-14 determination. Dr. J. Laurence Kulp reported an age determination of 2350 (±200) yr as marking the beginning of deposition of organic matter and doubtless of upland occupation by forests (*9*). During this 2350-yr period the shallow lake (10 ft) has filled in completely. Also, during this period the climate has cooled and become more humid. The change in climate very likely contributed to the establishment of the muskeg condition which favors a forest composed chiefly of black spruce (*Picea mariana*). At the present time the forest distribution is black spruce on muskegs and Jack pine in dry-rocky habitats. Observations from the plane show that much of that vast wilderness region is still in the formative period of forest development, with black spruce barely invading the muskegs.

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9. Recording number of the dating of the peat sample is Lamont No. 219.

April 22, 1954.

An Ethical Problem for Scientists in a Divided World

It is a sad fact that quacks and impostors arise from time to time to prey upon science. Sometimes they are merely a nuisance, but occasionally they become dangerous. The Lysenko scandal in the U.S.S.R. is the most shocking recent instance which has secured international notoriety. It belongs to the dangerous variety, and it would seem that exposing its true nature is a manifest responsibility of scientists competent to do so.

Responsibilities and ethics have, however, become blurred in our divided world. Several colleagues, both biologists and nonbiologists, have argued, in conversations, that nothing should be done that might weaken the domination of the biological sciences in the U.S.S.R. by Lysenko and his followers. Some have

even contended that Lysenko should be assisted to maintain his grip. The argument runs approximately as follows. So far as theoretical science is concerned, the so-called Michurinist biology is merely ludicrous. But Lysenko uses his "theories" in activities that are economically very important, like plant and animal breeding and general direction of agriculture. His influence in these affairs cannot help being disastrous, at least in the long run. Regardless of whether they know it or not, Lysenko and his followers are highly efficient saboteurs who weaken the economic fabric of the lands in which they secure domination. This activity is useful in cold war; it may be even more important in hot war.

This writer believes that the foregoing argument involves an ethical issue which should be discussed publicly. Like other humans, scientists are often mistaken; but no scientist should maintain scientific opinions that he knows to be untrue. Some confidence in each other's veracity and integrity is indispensable among scientists if science is to endure and to advance. Competent biologists know that Lysenko's theories are compounded of ignorance or fraud. These theories represent chiefly revivals of outworn notions which were current in scientific biology, mainly during the last century, and which were discarded, one by one, because they were shown, to the satisfaction of at least a large majority of biologists, to be invalid or useless. Of course, the history of science knows instances when a view that was temporarily abandoned eventually came into its own. But the very fact that Lysenko claims these theories to have been invented by Michurin or by himself shows that he either does not know or does not admit their real origin.

It is a remarkable and significant fact that among the many competent geneticists who worked in the U.S.S.R. prior to the establishment of Lysenko's domination in 1948, only one, Noujdin, has become an active protagonist of Lysenko's views. Concerning the others, the information is very scanty. To judge by the contents of the Russian scientific periodicals, those of the geneticists who remain alive and well have either abandoned biological research altogether or switched to "safe" topics. Despite all the threats and inducements they have not followed Lysenko. In the West, a majority of biologists have treated the Michurinist biology with contemptuous silence. To be sure, several books have been published in Lysenko's defence by authors whose primary competence lies in fields not too closely related to Lysenko's main activities. The origins of these books constitute an interesting problem in social psychology. Anyway, it is indisputable that Lysenkoism has very few followers among biologists outside of countries in which its acceptance is prescribed by governmental authority.

To urge that Lysenko's domination of the whole or of a part of biology in several countries is desirable means, then, to wish to perpetuate what a great majority of biologists consider to be an untruth. The present writer believes this to be incompatible with the moral obligations of a scientist. We should desire that scientific enlightenment penetrate everywhere, including the countries which are, for the time being, hostile to us. Let us admit that this involves a calculated risk. Science can be used for good as well as for bad ends. But it is perhaps not overoptimistic to believe that truth will ultimately make us free. Furthermore, a distinction must be drawn between basic science and technological knowledge. Some of the latter may and should be kept secret under certain circumstances. The former should not. Granted that the distinction will at times not be easy to make, it is our collective responsibility to make it. Basic biology certainly should not be made a weapon in any war. The very fact that such an ethical problem could have arisen is distressing; it shows the utter absurdity of a divided world.

THEODOSIUS DOBZHANSKY

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April 8, 1954.

A Challenge to Law

Lawson McKenzie's article on "Scientific property" [*Science* **118**, 764 (1953)] is something of a challenge to the changing law. Perhaps the law can contribute something to improving the social stature of the scientist by offering him new rights and responsibilities. If so, it could at the same time go a long way toward strengthening the weakest link in the chain of application of science generally.

The scientist enjoys a great deal of freedom but sometimes overlooks the fact that freedom implies responsibilities. One of his duties to his fellowmen is to see, as far as he reasonably can, that the fruits of his labor are accessible to all who can profitably harvest them, and not only to his fellow-scientists.

The scientist in the "ivory tower" is the greatest obstacle to the application of science to the common weal. He is likely to resent seeing his work reported in the popular press in what appear to him to be crude and inaccurate terms. He should reflect that there is no absolute truth—at least as far as expression in words is concerned, or even in thoughts. Different people have different habits of thought, and the scientist's—particularly if he has been trained in the "exact" sciences—are really very stylized. He can be about the worst person to choose for the task of getting his work applied in industry or agriculture. Moreover, he sometimes resents another person's cashing in on his discoveries. This is unjustified, for his rewards accrue from his reputation, as McKenzie observed, and all his work goes to his credit—even null results count. He is concerned with discovery, not invention. If he feels resentment at exploitation of his work by others, he should bear in mind that nothing succeeds like success; efforts to apply the fruits of scientific research fail much more often than they succeed, and an inventor or consultant benefits little from all his failures.

A lack of appreciation of the fact that science and

its application call for totally different disciplines of mind is responsible for much of the scientist's resentment in such instances. He has a sense of property in his creative mental work, but the law has not yet found a way to recognize this. If it does, then I venture to suggest that scientists will be bigger and better men and that the time lag in the application of science to industry, agriculture, and professional practices will diminish.

D. R. REXWORTHY

The Rubber Research Institute of Malaya, Kuala Lumpur

April 20, 1954.

D. R. Rexworthy's letter suggests an increasing social responsibility of the "ivory tower" scientist. I obliquely refer to this in a discussion of the scientific administrator on page 766 in the article of reference and directly in the previous article on the ONR Physics Branch Program [*Science* **118**, 227 (1953)].

UNESCO is at present considering the legal aspects of the problem [*UNESCO Copyright Bull.* **6**, No. 2 (1953)], and the American position seems to follow the older policy adopted in response to League of Nations inquiries in 1928. Rexworthy apparently approves of the UNESCO action to consider protection of "scientific property." I do not state my position since it would be only a value judgment.

All the arguments, pro and con, concerning invention and the patent system could quite nicely be applied to the analogous problem of discovery and legal protection of scientific "property." This is as far as I am willing to go, as I indicated in the concluding paragraph of the paper on scientific property.

LAWSON M. MCKENZIE

Washington 25, D.C.

April 26, 1954.

Need for a Standardized International Glossary of Terms in Botany

The formulation of the international rules of botanical nomenclature has been a landmark in the development of systematic botany and has cleared a lot of confusion from that field. There is, however, an equally great need of unanimity and exactitude in the definitions of descriptive terms in systematics and other branches of the subject. After all, what subject can claim to be a science without even having a precise terminology?

At present, various authors define a particular term in widely divergent ways and sometimes even give almost contrary definitions. The confusion prevailing in the terminology of inflorescences and placentations has already been discussed in detail by Rickett (*1*) and Puri (*2*), respectively. Rickett (*3*) has recently drawn attention, in what appears to be the first of a series of detailed articles on the topic, to the existence of a similar situation with regard to many other descriptive technical terms. But such confusions are not limited to these topics alone. Examples can be quoted from various fields and in any number. A few glaring random samples are cited in the following paragraphs.

The term *spike* is used for the strobilus of *Selaginella*, the fertile segment in *Ophioglossum* and other Ophioglossaceae and also for inflorescences of angiosperms. The misuse of the term *panicle* is too well known to be discussed here.

The term *bract* refers to such diverse objects as the sterile lobe of a sporophyll in Sphenophyllales, the sterile structures forming a whorl between the sporophylls in Equisetales, the scale subtending the so-called "ovuliferous scale" in the conifers [Florin (*4*) suggests an altogether different terminology for these structures], the leaves surrounding the fertile structures in the strobili of the Bennettitales, the leaflike structures around the perianth in *Nigella* [which are referred to as an "involucre of 5 leaves" by Willis (*5*, p. 450) and an "involucre of bracts" by Rendle (*6*, p. 141)]. Johnson (*7*, p. 705) defines a bract as a "much reduced leaf, as in an inflorescence or rhizome," while Willis (*5*, p. 92) regards it as "the leaf in whose axil a flower arises."

The term *flower* itself is much abused, being restricted by some to the fructifications of angiosperms and widely applied by others to those of the gymnosperms, for example, to Bennettitales, Cordaitales, Coniferales, Gnetales, and even to the strobili of pteridophytes like *Selaginella* (*8*).

The same type or even the same sepaloid, petaloid, differentiated or undifferentiated structures are called, at different places, *perianth*, *sepals*, or *petals* by the same or different authors. Most authors restrict the term *syngenesious* to such anthers as those of the Compositae and call the anthers of *Solanum connivant* (*7*, p. 531; *9*, p. 694) or *connate*; others call even those of *Solanum syngenesious* (*10*, p. 360). Similarly the staminal tube in some Malvaceae, for instance, *Hibiscus*, is refererd to as *adnate* or *joined* or *attached* to the petals (*9*, p. 592; *5*, p. 406; *6*, p. 249), although Rendle (*6*) at the same time records that the staminal tube is "considered to have arisen by the multiplication of five epipetalous members." Identical types of perigynous flowers are designated as having *half-inferior*, *sub-inferior* (*9*, p. 79) or *intermediate* (*5*, p. 477) ovaries by some, while others call such ovaries *superior* (*7*, pp. 63, 296; *11*, p. 179; *10*, p. 249).

There is also no uniformity in the use of symbols in floral formulas. Most authors denote perianth, calyx, corolla, androecium, and gynoecium by the letters P, K, C, A, and G, respectively. But Swingle (*12*) and Pool (*13*) use the symbols Ca, Co, S, and P for calyx, corolla, androecium, and gynoecium, respectively. These latter authors also use a different method of denoting the number of these parts, their cohesion or adnation, or their superior or inferior character in relation to the ovary, and so on. Many authors indicate by a plus (+) sign at one time an additional whorl, and at other times bundles in the same whorl.

The need for the precise definition of some other technical terms that denote the amount of quality of structures and the delimitation of the boundaries covered by each such term is equally great. Thus the terms *gamo-* or *poly- sepalous* or *petalous* are used to convey different amounts of fusion and freedom of sepals and petals; and *granular, punctate, tuberculate, verrucose, papillate, mammillate, muricate, echinate, spinose, hispid, hirsute, pilose, tomentose,* and so on, are used to denote different degrees of granulation, sculpturing, or hairiness by different authors. Accordingly, the reader is often unable to grasp the exact meaning of these terms, and there is a lot of scope for personal judgments and errors.

It cannot be denied that a certain amount of plasticity in the usage and meaning of technical terms is often necessary in a descriptive science; but at the same time it is equally important to know precisely what amount of variation each one of our terms covers. However, many of the present divergences in our terminology are unintentional, or are based on differing old views that are no longer valid, or are due to the lack of an authoritative glossary. This naturally leads to confusion and very often lands both students and teachers in difficulty.

It seems that anomalies such as the ones enumerated here have been encountered by many other botanists and have led to the formation of a section of terminology in the forthcoming International Botanical Congress. A committee should be formed for drafting an international glossary at this Paris congress; it should go through the whole problem and also frame rules for the formulation of new terms. A list of synonyms could also be drawn by this committee. It may be mentioned that wood anatomists long ago took the lead and compiled international glossaries of their technical terms (14).

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April 29, 1954.

Stable Colloidal Sulfur Solutions

In the course of an investigation on the microdetermination of mercaptans by their reduction of colloidal sulfur to hydrogen sulfide (*1*), the need arose for the preparation of a more stable and concentrated solution than is afforded by pouring a hot, saturated alcoholic solution of sulfur into water. It was found that any of the "Carbowaxes" (*2*), as well as propylene glycol, dissolve sulfur quite readily and produce stable colloidal solutions when poured into water. For example, a solution of sulfur may be prepared by dissolving 1.5 g of sulfur in 40 ml of Carbowax 200 at 110°C and adding it to 60 ml of cold water.

The colloidal solutions so prepared are free of electrolytes and hydrogen sulfide. The use of these solutions in determining microgram quantities of ethyl thioglycollate is being reported elsewhere (*3*).

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May 13, 1954.

Transplantability of Tumors

It has been reported by R. H. Foulkes [*Science* **119**, 124 (Jan. 22, 1954)] that benign tumors are incapable of further growth by transplantation. In an article on "The study of benign neoplasms of the rat's breast" [*Am. J. Cancer* **22**, 497 (1934)], I reported that six rats with spontaneous benign tumors yielded transplantable tumors from 4 to 53 generations. These tumors were under observation for some 15 yr at the Institute for Cancer Research, Columbia University. The variable morphology in different sex and age groups was described. The influence of hormones as growth stimulators or inhibitors was studied.

Other reports of experiments and results were as follows: *Am. J. Cancer* **27**, 450 (1936), **33**, 423 (1938), **39**, 172 (1940), **40**, 343 (1940); *Cancer Research* **2**, 25 (1942), **3**, 65 (1943); *Cancer* **2**, 329 (1949). The literature contains many other references on transplantability of benign mammary rat tumors: Willis, *Pathology of Tumors* (1948); Oberling *et al., Pathology; Year Book of Pathology and Immunology* (1941), and so on.

JACOB HEIMAN

15 West 81 Street, New York, N. Y.

March 5, 1954.

My overlooking the early and thorough study of Heiman was indeed a regrettable error. Malignancy and transplantability of tumors are still considered by many as almost synonymous. Publication of my brief note as confirmatory of the studies of Heiman and

others which have been brought to my attention would have been quite justifiable. The observations were made in the course of a study of other characteristics of the tumor in question which will be reported later.

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March 22, 1954.

Alas for Human Frailties!

As an English teacher and editor I fully agree with Eugene S. McCartney's admonitions in "Does writing make an exact man?" [*Science* Apr. 23, 1954]. But alas for human frailty! In the very paragraph in which Dr. McCartney deplores "errors of fact and lapses of memory" there occurs precisely such a fault —the more egregious because it is committed in the act of chastising another writer for a supposed mistake. What Dr. McCartney wrote is this:

> In a recent issue of our most literary magazine, a gifted scholar speaks of *Webster's New World Dictionary*, a glaring inadvertence that all readers of the manuscript and proof should have noticed. (The word *international* subconsciously suggested to the author the partial synonym *world*.)

The reference is to an article by Jacques Barzun in the Dec. 1953 issue of the *Atlantic Monthly*, and the error is not Dr. Barzun's, nor are the readers of Barzun's manuscript and proof deserving of rebuke. Dr. McCartney should have looked up before he leaped. Barzun praised and intended to praise *Webster's New World Dictionary of the American Language* (World Publishing Co., Cleveland, 1953), not *Webster's New International Dictionary*, published by the G. & C. Merriam Company; I know this because he made his purpose quite clear in correspondence with me about the *New World Dictionary*, of which I am general editor.

All of which, of course, merely underscores the validity of Dr. McCartney's exhortations and injunctions to writers. (But I confess to some slight surprise at the nodding of *Science's* editorial staff which let his slip pass in the night; after all, the NWD has been pretty widely advertised for over a year, and even Dr. Barzun's omission of the last four words of the full title—a common enough practice—ought not to have induced unwariness.)

JOSEPH H. FRIEND
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April 29, 1954.

Dr. McCartney, having seen Prof. Friend's letter, writes to us that the error he committed illustrates a point he made in his article, namely, that it is virtually impossible to write a perfect article. As for the "nodding of Science's editorial staff," the editor admits that he had let the existence of the dictionary in question slip completely out of his mind as a result of having read Carlton F. Well's review of it in The Saturday Review (of Literature) ***last year. As for the dictionary having been pretty widely advertised, the only publicity that we have seen—other than Prof. Well's unfavorable review—came out too late to be of help to us. We refer to Norman Cousin's editorial in*** The Saturday Review ***for May 15, page 24, and to the news item, "Editor's Decision," in*** Newsweek ***for May 24, page 58.***

Effects of Itrumil (New Antithyroid Agent) on the Histological Structure of the Rat Thyroid

The subcutaneous injection into mature male and female rats of 50 mg of Itrumil (5-iodo-2-thiouracil) dissolved in 2 ml of distilled water at room temperature for a period of 12 days produced the histological picture in the thyroid glands shown in Fig. 1. The daily dosage was injected in two equal amounts.

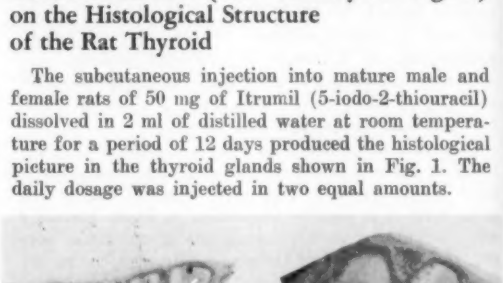

Fig. 1 (left). Photomicrograph (approximately ×100, enlarged 3 times) of cross sections of thyroid glands of rats subcutaneously injected with Itrumil. Fig. 2 (right). Photomicrograph (approximately ×100, enlarged 3 times) of cross sections of thyroid glands of untreated control rats.

The histological picture in Fig. 1 is similar to that described by Barrett, Gassner, and Dittmer (*1*) and by Barrett and Gassner (*2*). My results support those of Barrett and others in that the data and figures show that there are no histological differences between the thyroid glands of the untreated control animals shown in Fig. 2 and those of the experimental animals. In both groups the larger thyroid follicles were invariably at the periphery and surrounded by an epithelium of flattened cells, the smaller follicles were more centrally located and surrounded by an epithelium of cuboidal cells, and all follicles contained a good quality of colloid.

WALTER O. BRADLEY
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May 5, 1954.

A Simple Method for the Photographic Reproduction of Pencil Drawings

Because pencil illustrations are difficult to photograph, line drawings and graphs are commonly inked. Inking is time-consuming and, frequently, not without hazard! Illustration by pencil has advantages as pointed out by Clark (*1*) in his paper describing a pencil found to be suitable for photography.

The present paper describes a method whereby line drawings for photographic reproduction may be executed in ordinary pencil without regard to the reflectance properties of the lines (*2*). This is made possible by the use of transmitted light and photographic-paper of extreme contrast.

Although the process involves no more than contact printing, coupled with the use of high-contrast photosensitive material, I present it here since inking is the generally accepted method of preparing illustrations and since a search of the literature since 1926 has brought to light only two papers (*3, 4*) that bear on the subject, both of which might readily escape scientific workers. Moreover, they do not deal with copy for publication. Other papers may have appeared in the commercial literature.

The pencil illustration should be made on drawing paper or other nonopaque material. It is placed in a contact printer or frame so that the side bearing the illustration is away from the light source and in contact with the emulsion side of a piece of high-contrast photographic paper, such as Kodagraph Contact Extra Thin. After exposure through the original, a paper negative is produced upon development. The negative need be immersed only briefly in the fixer, rinsed for a moment, and blotted free of excess water before use.

If a transparency is wanted, the paper negative is photographed directly; if a copy for publication, it is printed by contact.

Figure 1 shows a camera lucida drawing of chromosomes and the word *Ink* prepared for reproduction by inking. Figure 2 was prepared in pencil only and copied by the present method of reproduction.

Once exposure times are determined, a negative and positive can both be produced in no more time than required for inking even simple illustrations. Autopositive paper, which yields a positive image directly, is also available, but the image is reversed laterally.

Fig. 1 (left). Drawing and lettering executed in ink. Fig. 2 (right). Drawing and lettering executed in pencil with no inking.

Advantages of the method are saving of time in inking; ability to prepare copies more readily and inexpensively than with camera copy; retention of the original and the ease of correction, alteration, or addition of parts at the paper-negative or positive-print stages.

Paper negative and positive must be thoroughly fixed and washed before storage. Blotters used for absorbing moisture from the paper negative while still charged with fixer must not be used for blotting fixer-free prints.

E. J. Britten

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May 3, 1954.

The Problem of the Carbonate Apatites

By completely ignoring one of the most fundamental principles, two Russian scientists, Borneman-Starinkevitch and Belov (*1*), have attempted to attack a recent paper of mine (*2*) that modified certain details of the structural hypothesis of Gruner and McConnell (*3*). It is regrettable that it is not possible to reply to their adverse discussion in the journal where it appeared—that is, *Comptes Rendus (Doklady) de l'Académie des Sciences de l'U.R.S.S.* Rather than attempting a detailed reply involving some of the minor complexities of the problem, which have been discussed in detail by numerous persons, these comments will be confined to some of the general questions raised by B.-S. and B. Nevertheless it will be necessary to reiterate the fundamental errors on which their claims are predicated.

B.-S. and B. (*1*) state that they find it necessary to indicate the "absurdity" of my hypothesis because of the "careless" quotation of these conclusions by Russian geologists. They do not cite specific references, but one may suppose that they refer to the results of Bushinsky (*4, 5*), Chukhrov (*6*), and possibly others. However, these general comments by B.-S. and B. seem somewhat pointless in view of the fact that Bushinsky and Chukhrov do not claim to have confirmed my results but merely call attention to their possible applicability to the enigma of the chemical composition of rock phosphates. Although I have commented on the petrography (*7*), as well as the chemical composition (*8, 9*) of rock phosphates, B.-S. and B. restrict their criticisms essentially to results bearing on the crystal structure of francolite.

The Russian authors (*1*) take pains to point out the omission of references to some of their earlier

comments (*10–13*) and seem to imply that I claim as original certain concepts supposedly introduced by them. As will subsequently appear, my views are markedly different from theirs in at least one fundamental respect. Thus their interpretation of my reason for omitting references to their papers does not seem reasonable, particularly in view of the fact that references to two of their papers (*10, 12*) are cited by McConnell and Gruner (*14*) in a paper which B.-S. and B. (*1*) do not cite but which was cited in my paper (*2*). In this same connection, they seem to attach some significance to omission of references to my own comments in the Russian literature (*15, 16*). Equal significance presumably could be attached to my omission of some of my other papers (*8, 17, 18*) on the same subject, but this sort of reasoning leads to an obvious absurdity.

Rather than being concerned with some obscure concepts presented during the interval 1938–40 by these Russians, I was concerned primarily with the results of Geiger (*19*) and of Brasseur and Dallemagne (*20*). Elsewhere (*8, 18*) the hypothesis of Hendricks and Hill (*21*) is discussed.

Although the views of Hendricks (*22*) stand in sharp contrast to my own in certain details, Hendricks agrees with me on one fundamental point: *the complete absence of any justification for assuming admixture of calcite* in pure samples of francolite. This is the fundamental point of divergence of B.-S. and B., who not only assume a specific and unjustifiable composition for carbonate apatite but also assume the necessity of calculating an admixture of calcite. Thus B.-S. and B. (*1*) reduce their own argument to an absurdity by calculating the chemical compositions to include a mineral phase that several authors have shown cannot be present. This point was adequately discussed in my paper (*2*), and references bearing on this subject were presented. Nevertheless, B.-S. and B. confine their attention to an attack on my hypothesis, without reference to that proposed by Hendricks and Hill (*21*) and, at the same time, completely disregard a fundamental premise of my hypothesis.

It becomes unnecessary, then, to reply in considerable detail to their remarks on the validity of such questions as interatomic distances, inasmuch as their assumptions include fundamental errors that completely invalidate their entire thesis.

For translations of Russian papers, I am indebted to Mrs. Justina D. Epp, Peter O. Krumin, and George S. Mitchell.

DUNCAN MCCONNELL
The Ohio State University, Columbus 10

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February 5, 1954.

Variation of Susceptibility to Polio

For 6 years I have been gathering data on a peculiar phenomenon that may be of interest to some readers. The data were gathered with the aid of numerous individual pediatricians and pediatric clinics. They pertain to an unexpected correlation between susceptibility to poliomyelitis and genetic traits indicated by pigmentation of skin, hair, and eyes.

The observations may be summarized thus: cases of polio investigated, 1183; polio patients with blond hair, blue eyes, and fair skin, 1; polio patients with blond hair, brown eyes, 17; polio patients with brown or black hair and eyes, 1165.

Obviously, these observed ratios differ significantly from the occurrence of light pigmentation in the general population. It is also noteworthy that the patients with light pigmentation had relatively light cases of the disease, and only two of them suffered any permanent impairment therefrom.

These observations pertain only to the members of the Caucasian race, since it was also noted that patients from other racial groups were in marked disproportion to their ratios in the general population.

It is felt that this variation of susceptibility to poliomyelitis should be taken into account in any statistical study of the value of prophylactic measures, since it is obvious that misleading results may be obtained unless there is an equal distribution of light- and dark-haired individuals in the control and experimental groups.

In the course of my investigations, I have met several pediatricians who had independently made the same observations, but I have not learned of any other attempt to gather objective data on this point. Any summary of pertinent data from readers or hypotheses of mode of influence would be greatly appreciated.

WALLACE L. MINTO
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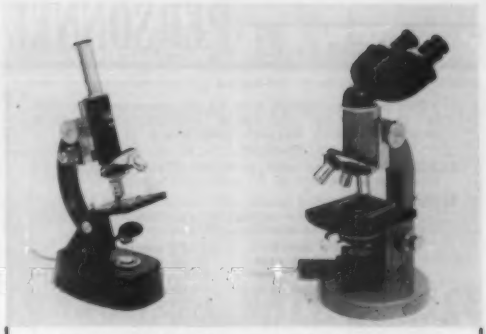

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New Books *(contd. from page 963)*

General Chemistry. A topical introduction. Eugene G. Rochow and M. Kent Wilson. Wiley, New York; Chapman & Hall, London, 1954. xiii + 602 pp. Illus. $6.

Advances in Cancer Research. Vol. II. Jesse P. Greenstein and Alexander Haddow, Eds. Academic Press, New York, 1954. xi + 530 pp. Illus. $11.

Cancer of the Lung: A Symposium. Johs. Clemmesen, Ed. Council for International Organisations of Medical Sciences, Paris, 1953 (Reprinted from ACTA). 210 pp. Illus. $6.

Geometrical Mechanics and De Broglie Waves. J. L. Synge. Part of Cambridge Monographs on Mechanics and Applied Mathematics, G. K. Batchelor and H. Bondi, Eds. Cambridge Univ. Press, New York, 1954. vi + 167 pp. Illus. $4.75.

The Nature of Light and Colour in the Open Air. Rev. ed. M. Minnaert. Trans. by H. M. Kremer-Priest; rev. by K. E. Brian Jay. Dover, New York, 1954 (Reprint of earlier ed.). xi + 362 pp. Illus. + plates. Cloth, $3.95; paper, $1.95.

The Properties of Glass. ed. 2. George W. Morey. ACS Monogr. Ser. No. 124, William A. Hamor, Ed. Reinhold, New York, 1954. 591 pp. Illus. $16.50.

Home Repairs and Improvements Emanuele Stieri. Barnes & Noble, New York, 1954 (Reprint of 1950 ed.). vii + 375 pp. Illus. Paper, $1.50.

Physics Principles. Stanley S. Ballard, Edgar P. Slack, and Erich Hausmann. Van Nostrand, New York–London, 1954. vi + 743 pp. Illus. $7.50.

Monomolecular Layers. A symposium presented at the Philadelphia meeting of the AAAS. Harry Sobotka, Ed. AAAS, Washington, D.C., 1954. vii + 207 pp. Illus. $4.25 (Members, $3.75).

The Principles of Physical Optics. An historical and philosophical treatment. Ernst Mach. Trans. by John S. Anderson and A. F. A. Young. Dover, New York, 1953 (Reprint of 1926 ed.). x + 324 pp. Illus. + plates. Cloth, $3.50; paper, $1.75.

Physical Meteorology. John C. Johnson. Technology Press, M.I.T., Cambridge; Wiley, New York; Chapman & Hall, London, 1954. xii + 393 pp. Illus. $7.50.

The Neolithic Cultures of the British Isles. Stuart Piggott. Cambridge Univ. Press, New York, 1954. xix + 420 pp. Illus. + plates. $13.50.

The Present State of Physics. A symposium presented on Dec. 30, 1949 at the New York meeting of the AAAS. Arranged by Frederick S. Brackett. AAAS, Washington, D.C., 1954. vi + 265 pp. Illus. $6.75. (Members, $5.75).

Nobel Prize Winners in Physics: 1901–1950. Niels H. de V. Heathcote. Schuman, New York, 1953. xvi + 473 pp. Illus. + plates. $8.50.

Differential Equations with Applications. Herman Betz, Paul B. Burcham, and George M. Ewing. Harper, New York, 1954. x + 310 pp. $4.50.

Organic Peroxides. Their chemistry, decomposition, and role in polymerization. Arthur V. Tobolsky and Robert B. Mesrobian. Interscience, New York–London, 1954. x + 197 pp. $5.75.

Introduction to Opinion and Attitude Measurement. H. H. Remmers. Harper, New York, 1954. viii + 437 pp. $5.

Southern African Mammals: 1758 to 1951. A reclassification. J. R. Ellerman, T. C. S. Morrison-Scott, and R. W. Hayman. British Museum (Natural History), London, 1953. 363 pp. Maps.

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Marine Tropicals. Ed L. Fisher. Sub-Marine Studios, Miami 32, 1954. 55 pp. Illus. $1.50.

Diet and Mastication: Their Effects on Diffusion and on the Inception of Dental Caries. Ronald B. Nevin. 43 pp. Illus. ***Experimental Observations on the Diet and Oral Hygiene in Relation to Dental Caries.*** Ronald B. Nevin. 15 pp. Illus. Progress Printing Co., Dunedin, New Zealand, 1954.

Professional Opportunities in Mathematics. ed. 2. Mathematical Assoc. of America, Univ. of Buffalo, Buffalo 14, 1954. 24 p. 25¢.

Contribution of Atomic Energy to Agriculture. Hearings before Subcommittee on Research and Development. Joint Committee on Atomic Energy, U.S. Senate, Washington 25, 1954. 87 pp. Illus.

Inter-relations between the Terrestrial Atmosphere and Cosmic Radiation. Prabhat K. Bhattacharya. Indian Physical Soc., Calcutta 32. 50 pp. Illus.

Frontiers of Man-controlled Flight. Proceedings of symposium presented at Los Angeles on Apr. 3, 1953. Heinz Haber, Ed. Inst. of Transportation and Traffic Engineering, Univ. of California, Berkeley 4, 1953. 109 pp. Illus. $2.

On the Dynamics of Hurricanes. Pt. I: ***The Eye of the Hurricane;*** Pt. II: ***The Vibrations of a Hurricane.*** Meteorological Papers, vol. 2, No. 2. Abdul Jabbar Adbullah. N.Y. Univ. Press, New York 3, 1953. 43 pp. Illus. $2.

Race Mixture. Harry L. Shapiro. UNESCO, Paris, 1953 (Order from Columbia Univ. Press, New York 27). 56 pp. 25¢.

Evaluation of C-band (5.5 cm) Airborne Weather Radar. H. T. Harrison and E. A. Post. United Air Lines, Denver, 1954. 108 pp. Illus.

Ninth Report of the Biological Bureau. (Nov. 1950–Apr. 1952). Game and Fisheries Dept., Prov. of Quebec, Montreal 2, 1953. 521 pp. Illus.

Bibliography of Canadian Biological Publications for 1949. J. Murray Speirs, Ruth Kingsmill, and George W. North. Quebec Biol. Bur. and Univ. of Toronto. 122 pp.

French Bibliographical Digest (Biology, botany, zoology). Ser. II, No. 9. Cultural Div. of the French Embassy, New York 21, 1953. 100 pp.

Building Research in Canada. vol. I, No. 6. Div. of Bldg. Res., National Res. Council, Ottawa, 1953. 31 pp. Illus.

Seventh Annual Report to American Cancer Society (July 1951–June 1952). Comm. on Growth, National Res. Council, Washington 25. 299 pp.

Symposium on Light Microscopy. Pub. No. 143. American Soc. for Testing Materials, Philadelphia 3, 1953. 126 pp. Illus.

Mécanismes Biochimiques de l'Activité des Antibiotiques (Penicilline, Streptomycine, Tyrothricine). Maurice-Marie Janot and Jean Keufer. Masson et Cie, Editeurs, Paris, 1953. 74 pp. 670 fr.

Diamond Pyramidal Hardness Testing of Spherical Specimens. Div. of Metrology Tech. Paper No. 1. J. A. Macinante and N. J. C. Peres. 11 pp. Illus. ***Design and Operation of an Electronic Temperature Controller.*** Div. of Metrology Tech. Paper No. 2. H. A. Ross and G. W. Gore. 32 pp. Illus. ***Some Overseas Developments in Surface Finish.*** Div. of Metrology Tech. Paper No. 3. C. A. Gladman. 34 pp. Illus. Commonwealth Scientific and Industrial Res. Organization, Melbourne, Australia, 1953.

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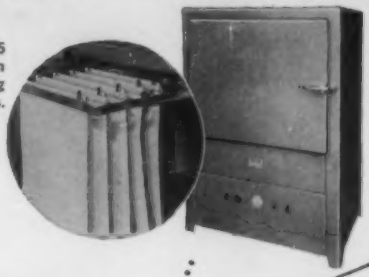

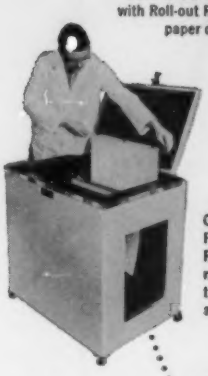

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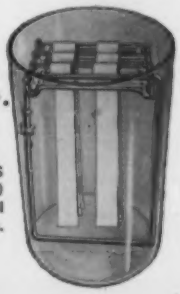

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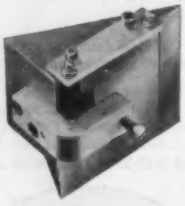

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